DOCUMENT RESUME

ED 054 964 SE 012 465

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TITLE Scientific and Technical Manpower Requirements of Selected Segments of the Atomic Energy Field. Final Report.

INSTITUTION Atomic Energy Commission, Oak Ridge, Tenn. Div. of Nuclear Education and Training.

PUB DATE Aug 70

NOTE 266p.

AVAILABLE FROM Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 ($2.00 Stock Number 5210-0267)

EDRS PRICE MF-$0.65 HC-$9.87

DESCRIPTORS Career Opportunities; *Employment Projections; Employment Statistics; Employment Trends; Engineers; *Nuclear Physics; *Occupational Surveys; Scientific Manpower; Scientists; *Technical Occupations

ABSTRACT

The primary purpose of the study was to develop a supply/demand ratio for nuclear degree scientists and engineers from July 1969 through 1973. The need by private industry and electric utilities for scientists and engineers with degrees in disciplines other than nuclear science or engineering, as well as for technicians, nuclear reactor operators, and nuclear materials managers is projected. The hiring practices of industries and utilities are related to the education received by the scientists and engineers required. The extrinsic and intrinsic factors used by companies and utilities active in the atomic energy field in developing technical manpower forecasts, the educational backgrounds of currently employed technical personnel, the level of degree work of these individuals, and the company and utility activities where the majority of the technical personnel work were identified. The results indicate a projected surplus of nuclear scientists or engineers, especially those with PhD's. A critical shortage of engineering talent is foreseen in the fields of mechanical and electrical/electronics engineering, as well as at the technician level. (Author/TS)

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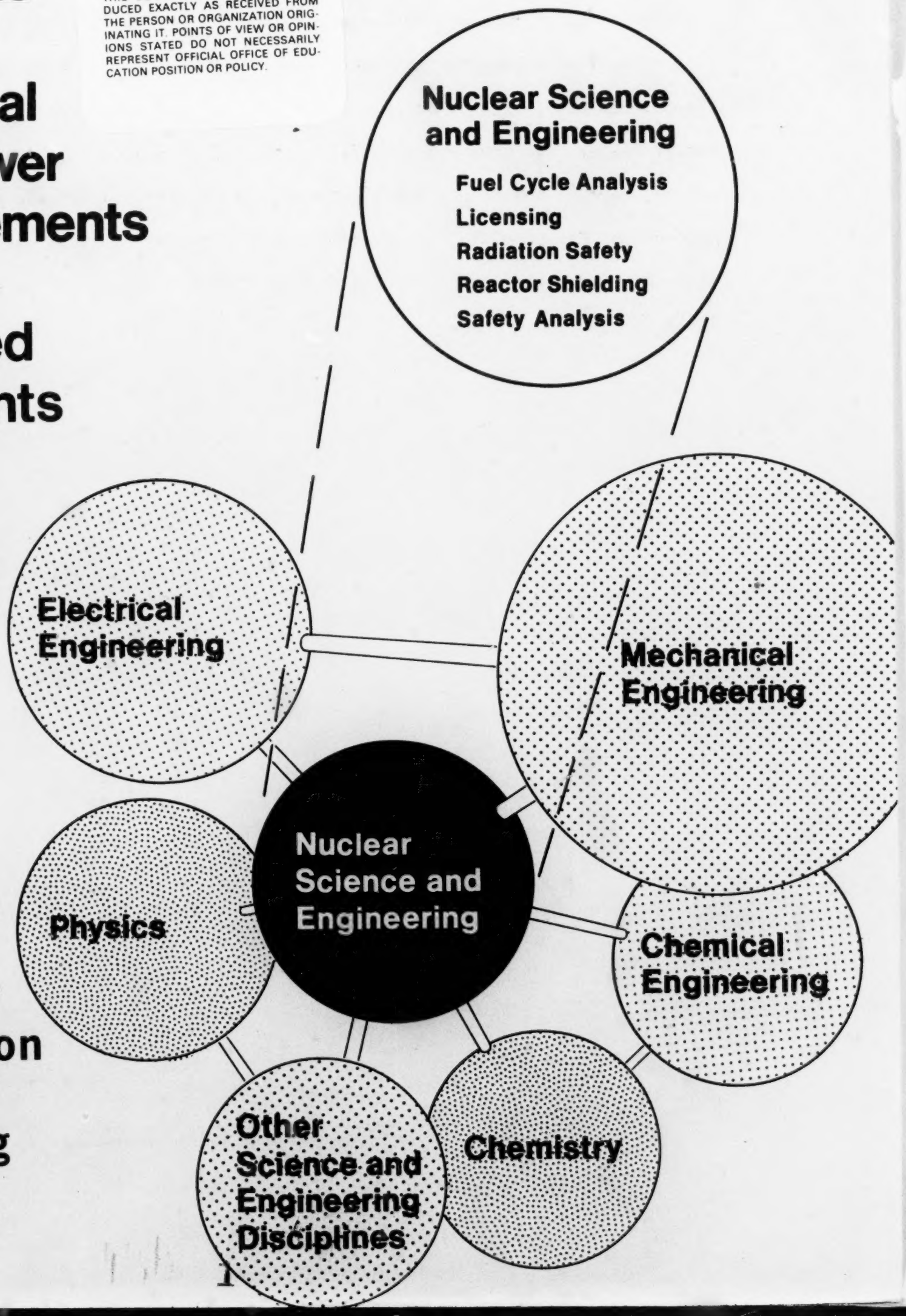
Scientific and Technical Manpower Requirements of Selected Segments of the Atomic Energy Field



Division of Nuclear Education & Training

USAEC

ABOUT THE COVER

The cover represents, in a graphical but perhaps simplistic way, the relationship of nuclear science and engineering to the classical science and engineering disciplines within the technical environment of industries active in the atomic energy field. The five subjects (i.e., fuel cycle analysis, licensing, radiation safety, reactor shielding, and safety analysis), listed under the caption "Nuclear Science and Engineering," represent the major job responsibilities of nuclear degreed individuals working in the private industry sector of the atomic energy field.

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PREFACE

This study and its associated research, data collection, and analyses was conducted by the American Nuclear Society under a contract for the Division of Nuclear Education and Training/U.S. Atomic Energy Commission. The primary purpose of the study was to quantify the technical manpower requirements of selected sectors of the atomic energy field through 1973. Not included in the study are the technical manpower requirements of government-owned-contractor-operated (GOCO) organizations (commission laboratories and defense production facilities), and state and federal services. However, summary employment information and an estimated demand for GOCO organizations have been included in the total evaluation.

The data included in the study represent only technical personnel who spend or will spend at least 50% of their working time in atomic energy activities.

Although the study was designed to project manpower requirements for scientists, engineers, technicians, nuclear reactor operators, and nuclear materials managers, it also placed considerable emphasis on the need for nuclear degreed scientists and engineers by the sectors of the atomic energy field covered in the study.

Another important objective of the study was to determine industry's evaluation of the education and training received by their technical employees in relation to the actual "on-the-job" requirements of the companies. In other words, are the universities giving their students what industry would consider as an adequate and meaningful education?

The subjective information was obtained from "in-depth" interviews conducted with sample companies representing each segment of the private industry sector and electric utility sector of the atomic energy field.

FOREWORD

This report of "Scientific and Technical Manpower Requirements of Selected Segments of the Atomic Energy Field" represents a much needed contribution to our understanding of the relationship between the expected needs for nuclear trained manpower in selected segments of the atomic energy field and the expected supply of people trained in the various aspects of nuclear science and engineering.

The main conclusion of the survey is that the expected supply of nuclear scientists and engineers will almost meet the expected demand in the near future. A greater shortage would be apparent if the requirements in the medical and Federal and state government segments had been surveyed and included. If the anticipated rapid expansion of the nuclear power industry is realized, the manpower shortage will become even more pronounced.

The survey was conducted with two limitations. First, it did not cover the requirements of medical institutions, Atomic Energy Commission laboratories and other government owned contractor operated (GOCO) establishments, and Federal and state government. However, in order to present a more balanced view of manpower needs, an estimate of employment in GOCO establishments, based on data from the Bureau of Labor Statistics of the Department of Labor, has been included in the summary tabulations. This estimate was based on the assumption that GOCO facilities would not expand and that only one-half of their normal attritional losses during the period covered by the survey would be replaced. The second limitation was that nuclear trained people who spent less than 50% of their time in atomic energy activities were not counted. Many of these require nuclear training. On the manpower supply side, however, essentially the whole was surveyed in that practically all colleges and universities with nuclear curricula were asked to estimate the number of students to be graduated in the various nuclear specialities. Notwithstanding the limitations under which the survey was conducted, the data developed are a valuable contribution to understanding the interface between supply of and demand for technically trained manpower in nuclear areas.

The report was produced for the Atomic Energy Commission by a special task force of the American Nuclear Society (ANS). Its conclusions do not necessarily reflect the attitude or policies of the Atomic Energy Commission. The ANS is to be commended for the thoroughness with which it has handled its assigned task and for providing a basis from which further studies of nuclear manpower requirements and supply may proceed.

Glenn T. Seaborg, Chairman
U.S. Atomic Energy Commission

-ACKNOWLEDGMENTS-

by

KEITH L. VOIGT, PROJECT MANAGER

On behalf of the American Nuclear Society, I would like to take this opportunity to thank the many individuals and organizations without whose help this study would not have been possible. Particular appreciation is extended to the 183 colleges and universities which completed the "Survey of Technical Manpower Requirements of Universities," the 42 electric utilities which completed the "Survey of Nuclear Trained Manpower Needs in Electric Power Industry," and the 68 companies which allowed their managers to take time from their busy schedules to participate in the "in-depth" interviews. I would like to thank the Division of Nuclear Education and Training/U.S. Atomic Energy Commission, Bureau of Labor Statistics, and National Science Foundation for their most helpful guidance and direction.

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NUCLEAR MANPOWER SURVEY

"SCIENTIFIC AND TECHNICAL MANPOWER REQUIREMENTS OF SELECTED SECTORS OF THE ATOMIC ENERGY FIELD"

-FINAL REPORT-

Prepared by the
American Nuclear Society
KEITH L. VOIGT, PROJECT MANAGER

For the Division of Nuclear Education and
Training/U.S. Atomic Energy Commission
DR. ELLIOT S. PIERCE, DIRECTOR

Contract Number AT(11-1)-2016

August 19, 1970
Hinsdale, Illinois

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PURPOSE AND SCOPE OF THE STUDY

The primary purpose of the study was to develop a supply/demand ratio for nuclear degreed scientists and engineers for the period extending from July 1969 through December 31, 1973. The study was also designed to obtain statistical information relating to the projected need by selected sectors of the atomic energy field for scientists and engineers with degrees in disciplines other than nuclear science or engineering, as well as for technicians, nuclear reactor operators, and nuclear materials managers. Such statistical data can be used not only as a quantitative measure of whether or not the educational institutions will be able to meet the technical manpower requirements of these sectors of the atomic energy field but also by government agencies and other interested organizations to evaluate their existing educational programs in light of the anticipated technical manpower needs of the electric utilities, educational institutions and private industry sector of the atomic energy field.

The study was also concerned with qualifying the technical manpower requirements of private industry and electric utilities by identifying the reasons why these organizations hire or do not hire nuclear degreed scientists and engineers, and, their evaluation of the education received by nuclear degreed and non-nuclear degreed scientists and engineers in relation to their technical requirements. In addition, the study was designed to identify not only the nuclear science and engineering courses most applicable to the technical requirements of companies and utilities active in the atomic energy field but also other existing or new technical or non-technical courses that should receive greater emphasis in the training of scientific and engineering personnel for employment in the atomic energy field.

Finally, the study attempted to identify the extrinsic and intrinsic factors used by companies and utilities active in the atomic energy field in developing technical manpower forecasts, the educational backgrounds of their currently employed technical personnel, the level of degree of these individuals, and the company and utility activities where the majority of their technical personnel work.

GENERAL FINDINGS

Prior to the onset of the ANS study, it was generally assumed that the annual demand by PRIVATE INDUSTRY, ELECTRIC UTILITIES, and GOCO facilities, for scientists and engineers with degrees in nuclear science or engineering (or major options in some areas of nuclear science), between July 1969 and December 31, 1973, would far outweigh the annual supply of these scientific and engineering types by the educational institutions. However, the results of the study showed this assumption to be partially incorrect. This is apparent if one looks at the total annual number of nuclear degreed scientists and engineers, at all levels of degree, that will be available for employment between July 1969 and the end of 1973 as projected in this study. However, it was previously stated that the initial assumption was <u>only partially</u> incorrect. This is because the results of the study show that although the overall projected demand for nuclear scientists and engineers, at all levels of degree, is greater than the projected supply of these types, the magnitude of the demand is less than originally assumed. There is a greater projected supply of nuclear engineers with PhD's than projected demand. This is also true in the case of nuclear scientists with PhD's. With regard to nuclear scientists and engineers with MS's and BS's, the projected demand for these types is only slightly greater than the projected supply.

The qualitative results of the study help to explain some of the reasons why private industry and the electric utilities do not plan to hire large numbers of PhD's (including nuclear scientists and engineers). Generally speaking, private industry and the electric utilities have or are in the process of undergoing a transformation from a research orientation to a product development (industry) and operational (utilities) orientation which do not require as much of the specialized technical knowledge as is required by pure and applied research endeavors. In addition, these organizations have found, through experience, that employees

with PhD's are generally too theoretical and too specialized to adapt to the new orientation of private industry and the electric utilities.

Another important finding was that these organizations foresee a critical shortage of engineering talent. This shortage will be especially acute in the fields of mechanical and electrical/electronics engineering.

In anticipation of this shortage of engineers, these organizations plan to hire a greater number of technician-level personnel to assume some of the engineer's responsibilities thus freeing the engineer for more productive, creative, and profitable endeavors. The problem here is that the demand for technician-level individuals will far exceed the supply.

Generally speaking, the study shows that only certain types of nuclear scientists and engineers are needed in substantial quantities by PRIVATE INDUSTRY, ELECTRIC UTILITIES, and the EDUCATIONAL INSTITUTIONS. The other major employment markets for nuclear scientists and engineers; namely, GOCO organizations (commission laboratories, and defense production facilities) and state and federal services, were not included in this study. Secondly, that the major problem facing these organizations is the projected shortage of classical engineers (i.e., mechanical, electrical, etc.). Thirdly, that in addition to an anticipated shortage of engineers, these organizations foresee a critical shortage of technician-level individuals.

Obviously, since the time the data were collected in early 1969, both the supply and demand situations have undergone changes which cannot be reflected in this report. However, because GOCO facilities constitute the largest employer of nuclear scientists and engineers, more current demand estimates for this group have been included at the request of the AEC in order to reflect as accurate a total evaluation as possible.

LIST OF PERTINENT TERMS

"NUCLEAR DEGREED"

Refers to those individuals who have received a formal degree in nuclear science or engineering. It is also used, in the context of this study, to include those individuals who have received a degree in some other science or engineering discipline but took nuclear science or engineering as a major option. (for example, a PhD in physics with a major option in nuclear physics.)

"NON-NUCLEAR DEGREED"

Refers to those individuals who have received a formal degree in a science or engineering discipline other than nuclear science or engineering. It does not include those individuals who received a degree in a science or engineering discipline other than nuclear science or engineering but took nuclear science or engineering as a major option.

"SECTOR"

Refers to an organizational classification of the atomic energy field. In this study, the SECTORS of the atomic energy field are; private industry, electric utilities, educational institutions, commission laboratories, defense production facilities, federal services, and other government-owned-contract-operated (GOCO) organizations.

"SEGMENT"

Refers to the functional classifications of the private industry sector of the atomic energy field such as; uranium milling, production of feed materials, production of special materials for use in reactors, fuel element fabrication and recovery activities, reactor and reactor component design and manufacturing, design and engineering of nuclear facilities, power reactor operation and manintenance, radioactive waste disposal, nuclear instrument manufacturing, processing and packaging of radioisotopes, particle accelerator manufacturing, private research laboratories, industrial radiography, and miscellaneous.

LIST OF PERTINENT TERMS

"CURRENT"

Refers to the year 1969 and, in particular, JULY 1969.

"ENTIRE, TOTAL, ALL, ETC."

Wherever these words appear in the context of the report, they refer only to those SECTORS of the atomic energy field covered by the study; namely, private industry, electric utilities, and educational institutions.

TIME PERIOD OF THE STUDY

The study covers only the period of time extending from JULY 1969 through DECEMBER 31, 1973.

ASSUMPTIONS USED IN THE STUDY

The basic assumption used by the survey participants in preparing estimates of their technical manpower requirements for 1970 and 1973 was that the present general economic conditions and trends would continue, including government support for research and development in nuclear and nuclear-related activities at about the same fraction of the gross national product as in the past. Secondly, that the availability of trained scientific and technical manpower at all levels of education adequate for their needs would be met. ("The present general economic conditions and trends," mentioned above, refer to the time at which the study was conducted - July 1969.)

WHAT THE STUDY PURPORTS TO BE

The study is but a "broadbrush" attempt to identify the general trends in requirements for technical personnel through 1973 by selected organizations active in the atomic energy field. The study was not designed to gather detailed information but rather an overview of the technical manpower picture in selected sectors of the atomic energy field. Because the study is the first comprehensive attempt to project technical manpower requirements of selected sectors of the atomic energy field and,

since the data are generalized, the results should be used only as a guideline or "starting point" from which more detailed studies and analyses can begin.

THE SURVEY'S MANPOWER PROJECTIONS

The data reported in this study represent the technical manpower projections of organizations active in selected sectors of the atomic energy field. The participating organizations projected their technical manpower requirements for 1970 and 1973 based on their current employment statistics and the survey assumptions outlined on the preceding page. Beyond the limitations of the assumptions, the respondents were free to use whatever manpower planning techniques they normally use in projecting their technical manpower requirements. As with most manpower projections, confidence in the data decreases the further one projects into the future. Although this study requested projections for only 4½ years, it is felt that the 1973 data are probably educated "guesses" and are generally optimistic in their outlook. However, it is felt that both the current employment data and the 1970 projections are reliable estimates of technical manpower requirements for the surveyed organizations under the conditions imposed by the assumptions.

IDENTIFICATION OF THE SECTORS OF THE ATOMIC ENERGY FIELD COVERED IN THE STUDY

The ONLY sectors of the atomic energy field covered by the study are the private industry sector, electric utilities sector, and educational institutions sector. NOT INCLUDED in the study are the technical manpower requirements of GOCO organizations (commission laboratories and defense production facilities) and state and federal services. However, estimates of GOCO employment and demands have been included in the total evaluation. In addition, the data reported in this study represents only technical personnel who spend or will be required to spend at least 50% of their working time in atomic energy activities.

CONCLUSIONS

Interspread throughout the CONCLUSIONS are the author's opinions and observations regarding both the quantitative and qualitative data presented in the report. These opinions and observations appear in *italics*. The reader should not interpret these opinions and observations as fact but rather as the opinions and observations the author concluded from his many discussions with the respondents. The author's remarks are <u>not</u> intended to influence the conclusions reached by the reader nor to force the reader to the author's point-of-view.

TECHNICAL MANPOWER REQUIREMENTS OF THE PRIVATE INDUSTRY SECTOR OF THE ATOMIC ENERGY FIELD

-STATISTICAL DATA-

(Refer to Tables 1 & 2 -- Pages 2 & 5)

1) The technical manpower requirements of the private industry sector of the atomic energy field will grow at a rate of more than 43% between July 1969 and December 31, 1973.

2) The private industry sector's requirements for technicians (including nuclear reactor operators and nuclear materials managers) to fill new positions will increase by almost 50%; scientists by approximately 42%; and, engineers by nearly 39% during the period of time extending from July 1969 through December 31, 1973.

3) Within the technician category, requirements for draftsmen between July 1969 and December 31, 1973 to fill new positions will increase by 1,896 followed by physical science technicians (758), other engineering technicians (751), and electrical/electronics technicians (737).

4) Again, within the technician category, health physics technicians and life science technicians show the largest percentage increase between July 1969 and December 31, 1973 (79% for health physics technicians and slightly less than 79% for life science technicians).

Table 1

PRIVATE INDUSTRY'S CURRENT (1969) EMPLOYMENT OF SCIENTISTS, ENGINEERS AND TECHNICIANS BY OCCUPATIONAL CATEGORIES AND ANS PROJECTIONS OF TECHNICAL MANPOWER REQUIREMENTS FOR 1970 AND 1973.

(Data include only personnel who spend at least 50% of their working time in atomic energy activities. Data do not include technical manpower requirements of the electric power utilities, educational institutions, government-owned-contractor-operated organizations, national laboratories, defense production facilities and federal services.)

OCCUPATIONAL CATEGORIES	CURRENT EMPLOYMENT	1970	INCREASE/ DECREASE	1973	INCREASE/ DECREASE
PHYSICAL SCIENTISTS	(12.9) 3,138	(12.7) 3,478	+340	(12.3) 4,305	+827
LIFE SCIENTISTS	(1.6) 393	(1.8) 494	+101	(2.0) 702	+208
ENGINEERS	(40.4) 9,831	(40.2) 10,995	+1,164	(38.8) 13,535	+2,540
MATHEMATICIANS	(1.7) 422	(1.7) 472	+50	(1.7) 601	+129
DRAFTSMEN	(12.7) 3,074	(13.2) 3,607	+533	(14.2) 4,970	+1,363
ELECTRICAL & ELECTRONICS TECHNICIANS	(6.7) 1,617	(6.5) 1,779	+162	(6.7) 2,354	+575
OTHER ENGINEERING TECHNICIANS	(8.6) 2,090	(8.0) 2,207	+117	(8.1) 2,841	+634
HEALTH PHYSICS TECHNICIANS & RADIATION MONITORS	(1.9) 461	(2.2) 591	+130	(2.4) 825	+234
LIFE SCIENCE TECHNICIANS	(0.6) 145	(0.7) 192	+47	(0.8) 259	+67
PHYSICAL SCIENCE TECHNICIANS	(6.5) 1,581	(6.5) 1,782	+201	(6.7) 2,339	+557
OTHER TECHNICIANS	(5.2) 1,264	(5.2) 1,415	+151	(5.1) 1,769	+354
NUCLEAR REACTOR OPERATORS	(1.0) 234	(1.0) 266	+32	(0.9) 300	+34
NUCLEAR MATERIALS MANAGERS	(0.2) 56	(0.3) 76	+20	(0.3) 113	+37
TOTALS	(100.0) 24,306	(100.0) 27,354	+3,048	(100.0) 34,913	+7,559

5) Of all the scientists categories, the life scientists show the largest percentage increase (almost 79%) between July 1969 and December 31, 1973.

6) Of the total number of currently (1969) employed scientists and engineers working in the private industry sector of the atomic energy field, about 13% have nuclear science or nuclear engineering degrees.

7) Nuclear engineers comprise the largest number (1,196) of the currently (1969) employed nuclear degreed scientists and engineers covered by the survey.

8) Over 78% of the currently (1969) employed nuclear degreed scientists and engineers covered by the survey have advanced degrees while less than 32% of the other degreed (non-nuclear) scientists and engineers have advanced degrees.

9) Between July 1969 and December 31, 1973, 808 nuclear scientists and 1,086 nuclear engineers will be required by the private industry sector of the atomic energy field to fill new and replacement positions.

10) Of these nearly 1,900 nuclear scientists and engineers, the percentage that will be hired by each industrial segment of the private industry sector of the atomic energy field between July 1969 and December 31, 1973 are:

Industrial Segments	Percent Distribution of the Estimated New and Replacement Hires of Scientists and Engineers with Nuclear Science or Engineering Degrees by Each Industrial Segment within the Private Industry Sector of the Atomic Energy Field for the Period Extending from July 1969 through December 31, 1973
Reactor & Reactor Component Design and Manufacturing	47.6%
Private Research Laboratories	25.6%
Design & Engineering of Nuclear Facilities	11.7%
Fuel Element Fabrication & Recovery Activities	7.1%
Processing and Packaging Radioisotopes	3.0%
Nuclear Instrument Manufacturing	2.6%
Production of Feed Materials	1.5%

CONCLUSIONS

Industrial Segments	Percent Distribution of the Estimated New and Replacement Hires of Scientists and Engineers with Nuclear Science or Engineering Degrees by Each Industrial Segment within the Private Industry Sector of the Atomic Energy Field for the Period Extending from July 1969 through December 31, 1973
Particle Accelerator Manufacturing	0.6%
Miscellaneous	0.3%

11) Companies active in uranium milling, production of special materials for use in reactors, radioactive waste disposal and industrial radiography activities of the private industry sector of the atomic energy field have not hired nor do they plan to hire nuclear scientists and/or engineers through 1973.

-IN-DEPTH INTERVIEWS-

1) Industry generally believes that although nuclear scientists and engineers are quite capable within their field of specialization they are too theoretically oriented.

This criticism will become more apparent in the near future as these organizations have begun to hire more nuclear scientists and engineers for operational rather than research responsibilities.

2) Excluding the large nuclear reactor and reactor component manufacturers, companies generally hire nuclear scientists and engineers to fill a technological void currently existing within their organization.

By hiring such a specialist, the companies not only fill their technological void but, by so doing, the companies are able to compete in the atomic energy field. Typically, the nuclear scientist and/or engineer is hired not only to establish the company's nuclear capability but also to train the company's (non-nuclear) technical staff in nuclear technology.

3) For the companies that hire nuclear degreed individuals, there is an overall de-emphasis on the hiring of PhD's with a corresponding emphasis on the hiring of MS's.

4) The companies in the industrial segments covered by the survey assume that the current rate of production of MS's will continue and, therefore, do not foresee

Table 2

PRIVATE INDUSTRY'S CURRENT (1969) EMPLOYMENT OF SCIENTISTS AND ENGINEERS WITH DEGREES IN NUCLEAR SCIENCE AND ENGINEERING AND ANS PROJECTIONS OF REQUIREMENTS FOR THESE TECHNICAL PERSONNEL FOR 1970 AND 1973.

(Data include only personnel who spend at least 50% of their working time in atomic energy activities. Data do not include technical manpower requirements of the electric power utilities, educational institutions, government-owned-contractor-operated organizations, national laboratories, defense production facilities and federal services.)

OCCUPATIONAL CATEGORIES	CURRENT EMPLOYMENT	1970	INCREASE/ DECREASE	1973	INCREASE/ DECREASE
SCIENTISTS (Life & Physical)	(40.2) 682	(40.5) 835	+153	(40.1) 1,108	+273
ENGINEERS	(59.8) 1,013	(59.5) 1,229	+216	(59.0) 1,595	+366
TOTALS	(100.0) 1,695	(100.0) 2,064	+369	(100.0) 2,703	+639

any difficulty in filling their need for nuclear scientists and engineers in the near future.

5) In the educational training of nuclear engineers, the companies would like the educational institutions to place more emphasis on reactor fuel technology, reactor materials, reactor design and analysis, fuel-cycle management, fuel-cycle analysis, control theory, systems engineering, and radiochemistry.

6) The overwhelming opinion of the interviewed comapnies was that the BS degree in nuclear engineering typically results in an individual with "tunnel vision" who, because of his specialization too early in his career, becomes inflexible and "pigeonholed" in the company.

The companies normally hire BS nuclear engineers for what they can do for the company today. And, unless this individual has managerial potential or broadens his background in some other engineering discipline, his advancement within the organization is hindered.

7) There are many companies which do not really know what a nuclear engineer does. Furthermore, there are many companies which believe they can adequately compete in the nuclear field with their existing staff.

This belief is shortsighted when one considers the increasing demand for more sophisticated products, materials, and services in the atomic energy field. More than ever before, the demand for these products, materials, and services will require the very specialized knowledge offered by nuclear scientists and engineers.

8) The interviewed companies are relatively confident about the future supply of scientists in general. However, the vast majority of the interviewed companies are quite pessimistic concerning the future supply of engineers (i.e., mechanical, electrical, etc.).

9) The companies would encourage the universities to keep "up-to-date" on the latest technologies by incorporating immediate coverage of these new developments in their classical scientific and engineering curriculums.

10) Probably the most urgent problem confronting private industry is the shortage of qualified technicians. With the anticipated shortage of engineers, the

companies want to hire more technicians so as to relieve their engineers for more productive and profitable endeavors.

TECHNICAL MANPOWER REQUIREMENTS OF THE ELECTRIC UTILITIES SECTOR OF THE ATOMIC ENERGY FIELD

-STATISTICAL DATA-

(Refer to Tables 17, 18, & 19 -- Pages 8, 9, & 10)

1) The technical manpower requirements of the electric utilities will grow at an overall rate of 181% between July 1969 and December 31, 1973.

2) The average number of personnel per nuclear generating plant is about 78 (based on the 1973 manpower estimates for 96 nuclear power plants in operation by 1977). Of these 78 employees per plant, 51 will work at the plant site while the remaining 27 employees will be part of the utilities' central office staff.

3) Of the 78 employees per plant, 87% working at the plant site will have no degrees while 76% working at the central office will have formal degrees (based on the 1973 employment estimates).

4) Between July 1969 and December 31, 1973, personnel working at the plant site will increase by 288% (3,629). The central office staff will increase by 85% (1,176) during the same time period.

5) As a utility system builds additional nuclear power plants, personnel working at the plant site increase while the central office staff remains relatively constant.

6) By December 31, 1973, there will be 1 senior reactor operator (supervisory position) for every 2.3 reactor operators (operating position).

7) The electric utilities are planning to hire 938 technician-level personnel between July 1969 and December 31, 1973. They are also planning to hire 2,582 "other" people who, although not considered as professional technicians, will

Table 17

– ELECTRIC POWER UTILITIES –

CURRENT (1969) EMPLOYMENT OF PERSONNEL BY COMPANY ACTIVITY, DEGREE VERSUS NON-DEGREE AND LEVEL OF DEGREE.

(Data include only personnel employed by electric power utilities that have or are planning to have a nuclear power plant(s) in operation by 1977. Only personnel who have had "some" nuclear training are included.)

	FUNCTIONS	TOTALS	NON-DEGREE	DEGREE	LEVEL OF DEGREE		
					PhD	MS	BS
ON-SITE	GENERAL & OPERATIONS	632	539	93	---	8	85
ON-SITE	MAINTENANCE	225	215	10	---	---	10
ON-SITE	TECHNICAL SERVICES	404	266	138	2	20	116
	TOTAL – ON-SITE	**1,261**	**1,020**	**241**	**2**	**28**	**211**
OFF-SITE	DESIGN & SAFETY ANALYSIS	633	20	613	4	102	507
OFF-SITE	RESEARCH & DEVELOPMENT	39	4	35	---	11	24
OFF-SITE	CONSTRUCTION	129	20	109	---	7	102
OFF-SITE	OPERATIONS & FUEL CYCLE MANAGEMENT	164	21	143	4	34	105
OFF-SITE	PERIODIC MAINTENANCE	276	253	23	---	2	21
OFF-SITE	ADMINISTRATION	147	2	145	---	22	123
	TOTAL – OFF-SITE	**1,388**	**320**	**1,068**	**8**	**178**	**882**
	GRAND TOTALS	**2,649**	**1,340**	**1,309**	**10**	**206**	**1,093**

Table 18

– ELECTRIC POWER UTILITIES –

ESTIMATED 1970 EMPLOYMENT OF PERSONNEL BY COMPANY ACTIVITY, DEGREE VERSUS NON-DEGREE AND LEVEL OF DEGREE.

(Data include only personnel planned for employment by electric power utilities in 1970 that have or are planning to have a nuclear power plant(s) in operation by 1977. Only personnel who have had or will be required to have "some" nuclear training are included.)

	FUNCTIONS	TOTALS	NON-DEGREE	DEGREE	LEVEL OF DEGREE		
					PhD	MS	BS
ON-SITE	GENERAL & OPERATIONS	1,461	1,312	149	---	9	140
	MAINTENANCE	833	812	21	---	---	21
	TECHNICAL SERVICES	846	554	292	2	45	245
TOTAL – ON-SITE		3,140	2,678	462	2	54	406
OFF-SITE	DESIGN & SAFETY ANALYSIS	862	36	826	5	146	675
	RESEARCH & DEVELOPMENT	48	5	43	---	12	31
	CONSTRUCTION	199	37	162	---	5	157
	OPERATIONS & FUEL CYCLE MANAGEMENT	319	59	260	7	61	192
	PERIODIC MAINTENANCE	392	362	30	---	5	25
	ADMINISTRATION	171	4	167	---	27	140
TOTAL – OFF-SITE		1,991	503	1,488	12	256	1,220
GRAND TOTALS		5,131	3,181	1,950	14	310	1,626

Table 19

– ELECTRIC POWER UTILITIES –

ESTIMATED 1973 EMPLOYMENT OF PERSONNEL BY COMPANY ACTIVITY, DEGREE VERSUS NON-DEGREE AND LEVEL OF DEGREE.
(Data include only personnel planned for employment by electric power utilities in 1973 that have or are planning to have a nuclear power plant (s) in operation by 1977. Only personnel who have had or will be required to have "some" nuclear training are included.)

FUNCTIONS		TOTALS	NON-DEGREE	DEGREE	LEVEL OF DEGREE		
					PhD	MS	BS
ON-SITE	GENERAL & OPERATIONS	2,279	2,089	190	---	9	181
	MAINTENANCE	1,369	1,332	37	---	---	37
	TECHNICAL SERVICES	1,242	833	409	3	52	354
TOTAL – ON-SITE		**4,890**	**4,254**	**636**	**3**	**61**	**572**
OFF-SITE	DESIGN & SAFETY ANALYSIS	1,100	37	1,063	6	184	873
	RESEARCH & DEVELOPMENT	57	6	51	---	16	35
	CONSTRUCTION	254	50	204	---	6	198
	OPERATIONS & FUEL CYCLE MANAGEMENT	487	86	401	6	89	306
	PERIODIC MAINTENANCE	456	413	43	---	8	35
	ADMINISTRATION	210	14	196	---	33	163
TOTAL – OFF-SITE		**2,564**	**606**	**1,958**	**12**	**336**	**1,610**
GRAND TOTALS		**7,454**	**4,860**	**2,594**	**15**	**397**	**2,182**

receive "some" nuclear training prior to their plant assignment. (These "other" people do not include clerks, secretaries, guards, etc.)

8) There will be a significant increase, percentagewise, in the number of scientists the utilities plan to hire between July 1969 and December 31, 1973.

9) Between July 1969 and December 31, 1973, the electric utilities are planning to hire a total of 413 nuclear scientists and engineers to fill new and replacement positions. Of these 413 individuals, 52 will be nuclear scientists and 361 will be nuclear engineers. By December 31, 1973, nearly 54% of these nuclear scientists and engineers will have only BS degrees.

-IN-DEPTH INTERVIEWS-

1) The electric utilities that do not now have a nuclear power plant are taking a "wait and see" attitude regarding the performance, economics, and social considerations of nuclear power plants now being built or in operation.

2) In forecasting their long-range technical manpower requirements, the electric utilities place considerable emphasis on what the "state of the art" of the utility industry will be in the future.

3) When hiring a man to meet their short-range manpower requirements, the utilities look for the individual who has had the necessary experience to fill the utility's technical need today. However, when the utilities hire an individual to fill a long-range manpower need, they tend to hire the man for his potential usefulness.

4) The electric utilities have had and will continue to have difficulty in hiring enough engineers to meet their requirements. In particular, there will be a shortage of mechanical engineers and engineers experienced in quality control engineering.

5) The electric utilities believe it is unfortunate that there are only a few courses (graduate) in the classical engineering curriculums specifically designed for the power industry.

CONCLUSIONS

6) Although the interviewed electric utilities indicated they would like their degreed (non-nuclear) scientists and engineers to have some background in nuclear technology, they prefer to have these employees take short or semester nuclear courses only after they have worked at the utility for a period of time.

7) Nearly 60% of the interviewed electric utilities have been quite successful in filling their needs for nuclear scientists and engineers.

8) The electric utilities have increased their requirements for nuclear degreed individuals during the past five years primarily because of:

   a. the construction of nuclear power plants,

   b. increased nuclear power plant construction and operation requirements of Federal regulatory agencies, and

   c. an increased awareness of the technical benefits the nuclear engineers bring to the utility.

9) The electric utilities favor hiring nuclear engineers from schools that have training reactors.

10) In general, the electric utilities would like nuclear engineers to have more coursework in quality control and quality assurance. Furthermore, at the BS level, the nuclear engineer seems to be weak in fluids, heat transfer and strength of materials technologies.

11) *There are still quite a few utilities that are unwilling to pay competitive salaries for qualified professional employees.*

12) With regard to the hiring of technician-level personnel, one of the major problems facing the utilities is the wage and hourly union agreements which have limited the utilities' ability to bring in experienced and skilled personnel at company levels higher than what a typical union employee would be brought in at.

13) *The electric utility industry must create a better image of itself if it expects to attract quality people. The utility industry will have to compete for top college talent, which it desparately needs, by offering exciting and challenging work and an opportunity to contribute to the social and community problems currently plaguing the electric utilities.*

TECHNICAL MANPOWER REQUIREMENTS OF THE EDUCATIONAL INSTITUTION SECTOR OF THE ATOMIC ENERGY FIELD

-STATISTICAL DATA-

(Refer to Tables 25, 26, 27 & 28 -- Pages 14, 15, 16, & 17)

1) The rate of growth of technical manpower requirements at the educational institutions between July 1969 and December 31, 1973 is 34.4%.

2) The universities are planning to place more emphasis on both the teaching of and the research and development in nuclear engineering, health physics, radiation applications, and radiation biology.

3) Based on the assumption that all new and replacement positions (nuclear science and engineering faculty, research and development personnel and nuclear facilities personnel) at the universities will be filled with only nuclear degreed scientists and engineers, there will be a total demand of 1,392 nuclear scientists and 408 nuclear engineers between July 1969 and December 31, 1973.

4) Almost 95% of the nuclear science and engineering faculty will have PhD's by December 31, 1973.

5) Between July 1969 and December 31, 1973, the universities will need an additional 625 scientists, 205 engineers, and 138 technicians to fill new positions. (Nuclear science and engineering faculty, research and development personnel and nuclear facilities personnel.)

6) Requirements for the educational institutions' nuclear facilities staff will show the largest percentage increase between July 1969 and December 31, 1973 (36%) followed closely by faculty (35%), and research and development personnel (33%).

Table 25

– EDUCATIONAL INSTITUTIONS –

CURRENT (1969) EMPLOYMENT OF FACULTY TEACHING IN THE NUCLEAR FIELD BY LEVEL OF DEGREE AND NUCLEAR SCIENCE OR ENGINEERING DISCIPLINE BEING TAUGHT AND ANS PROJECTIONS OF FACULTY REQUIREMENTS FOR 1970 AND 1973 – Includes full-time FACULTY and 50% of the reported part-time FACULTY.

(Data include only faculty from schools which completed the ANS survey questionnaire and which offer degrees and/or courses in nuclear science and engineering. Data do not include full-time RESEARCH AND DEVELOPMENT or NUCLEAR FACILITIES PERSONNEL.)

DISCIPLINE	Currently Employed				Planned 1970				Planned 1973			
	PhD	MS	BS	Totals	PhD	MS	BS	Totals	PhD	MS	BS	Totals
Nuclear Physics	425	20	5	450 (35.2)	470	18	1	489 (33.6)	551	14	3	568 (32.9)
Thermonuclear Physics	29	–	–	29 (2.3)	52	–	–	52 (3.5)	64	–	–	64 (3.7)
High Energy Physics	248	1	–	249 (19.5)	285	1	–	286 (19.7)	340	–	–	340 (19.7)
Nuclear and Radiation Chemistry	89	6	1	96 (7.5)	93	4	2	99 (6.8)	115	4	3	122 (7.1)
Reactor Engineering	109	25	4	138 (10.8)	131	22	4	157 (10.8)	154	22	6	182 (10.5)
Other Nuclear Engineering	91	9	2	102 (8.0)	120	9	2	131 (9.0)	150	10	3	163 (9.4)
Radiation Applications	54	9	2	65 (5.1)	65	12	1	78 (5.4)	82	10	–	92 (5.3)
Health Physics	34	13	2	49 (3.8)	50	12	1	63 (4.3)	57	13	2	72 (4.2)
Radiation Biology	93	6	–	99 (7.8)	89	11	–	100 (6.9)	113	11	1	125 (7.2)
Totals	1,172	89	16	1,277 (100.0)	1,355	89	11	1,455 (100.0)	1,626	84	18	1,728 (100.0)
Totals by time period	1,277				1,455				1,728			

Table 26

– EDUCATIONAL INSTITUTIONS –

CURRENT (1969) EMPLOYMENT OF RESEARCH AND DEVELOPMENT PERSONNEL BY LEVEL OF DEGREE AND NUCLEAR SCIENCE AND ENGINEERING DISCIPLINE BEING INVESTIGATED AND ANS PROJECTIONS OF RESEARCH AND DEVELOPMENT PERSONNEL REQUIREMENTS FOR 1970 AND 1973 – Includes full-time RESEARCH AND DEVELOPMENT PERSONNEL and 50% of the reported part-time RESEARCH AND DEVELOPMENT PERSONNEL.

(Data include only research and development personnel from schools which completed the ANS survey questionnaire and which offer degrees and/or courses in nuclear science and engineering. Data do not include full-time FACULTY or NUCLEAR FACILITIES PERSONNEL.)

DISCIPLINE	Currently Employed					Planned 1970					Planned 1973				
	PhD	MS	BS	Tech	Totals	PhD	MS	BS	Tech	Totals	PhD	MS	BS	Tech	Totals
Nuclear Physics	138	43	33	84	298 (25.8)	158	41	35	84	318 (26.6)	212	58	50	97	417 (27.1)
Thermonuclear Physics	6	4	1	6	17 (1.4)	24	3	5	12	44 (3.6)	27	3	5	15	50 (3.3)
High Energy Physics	97	24	37	282	440 (38.0)	114	9	35	226	384 (32.1)	166	9	49	261	485 (31.6)
Nuclear and Radiation Chemistry	57	8	4	16	85 (7.3)	56	1	6	16	79 (6.6)	59	7	10	19	95 (6.2)
Reactor Engineering	14	15	7	17	53 (4.6)	13	16	10	23	62 (5.2)	25	15	11	25	76 (4.9)
Other Nuclear Engineering	13	24	24	28	89 (7.7)	13	31	25	29	98 (8.2)	17	41	41	37	136 (8.8)
Radiation Applications	26	19	8	21	74 (6.4)	24	21	15	28	88 (7.4)	30	26	24	36	116 (7.5)
Health Physics	9	7	6	9	31 (2.7)	10	9	8	10	37 (3.1)	12	10	9	18	49 (3.2)
Radiation Biology	26	9	6	29	70 (6.1)	32	6	11	37	86 (7.2)	38	12	16	47	113 (7.4)
Totals	386	153	126	492	1,157	444	137	150	465	1,196	586	181	215	555	1,537
Totals by time period	1,157					1,196					1,537				

Table 27

– EDUCATIONAL INSTITUTIONS –

CURRENT (1969) EMPLOYMENT OF NUCLEAR FACILITIES PERSONNEL BY LEVEL OF DEGREE AND EMPLOYMENT TITLE AND ANS PROJECTIONS OF NUCLEAR FACILITIES PERSONNEL REQUIREMENTS FOR 1970 AND 1973 – Includes full-time NUCLEAR FACILITIES PERSONNEL and 50% of the reported part-time NUCLEAR FACILITIES PERSONNEL.
(Data include only nuclear facilities personnel from schools which completed the ANS survey questionnaire and which offer degrees and/or courses in nuclear science and engineering. Data do not include full-time FACULTY or RESEARCH AND DEVELOPMENT PERSONNEL.)

AREA	Currently Employed					Planned 1970					Planned 1973				
	PhD	MS	BS	Tech	Totals	PhD	MS	BS	Tech	Totals	PhD	MS	BS	Tech	Totals
Reactor Supervisors	7	27	10	6	50 (13.2)	5	20	16	5	46 (11.0)	6	17	16	6	45 (8.8)
Reactor Operators	5	12	20	58	95 (25.1)	7	15	30	75	127 (30.3)	7	14	33	85	139 (27.0)
Accelerator Supervisors	9	8	10	21	48 (12.7)	10	10	9	21	50 (11.9)	13	16	8	24	61 (11.8)
Accelerator Operators	2	6	22	68	98 (25.9)	5	15	19	69	108 (25.8)	5	29	21	98	153 (29.7)
Radiation Safety Officer (Health Physicist)	16	28	22	21	87 (23.1)	14	28	24	22	88 (21.0)	13	30	38	36	117 (22.7)
Totals	39	81	84	174	378	41	88	98	192	419	44	106	116	249	515
Totals by time period	378					419					515				

Table 28

– EDUCATIONAL INSTITUTIONS –

CURRENT (1969) ENROLLMENT OF STUDENTS IN COURSEWORK LEADING TO DEGREES IN NUCLEAR SCIENCE OR ENGINEERING BY LEVEL OF DEGREE EARNED AND NUCLEAR SCIENCE OR ENGINEERING DISCIPLINE IN WHICH DEGREE WAS EARNED AND ANS PROJECTIONS OF STUDENT ENROLLMENTS FOR 1970 AND 1973.

(Data include only student enrollments from schools which completed the ANS survey questionnaire and which offer degrees and/or courses in nuclear science and engineering.)

DISCIPLINE	Current				Planned 1970				Planned 1973			
	PhD	MS	BS	Totals	PhD	MS	BS	Totals	PhD	MS	BS	Totals
Nuclear Physics	653	221	437	(28.3) 1,311	739	352	484	(26.2) 1,575	896	436	599	(27.3) 1,931
Thermonuclear Physics	63	15	10	(1.9) 88	100	34	12	(2.4) 146	129	21	5	(2.2) 155
High Energy Physics	423	41	22	(10.5) 486	501	56	20	(9.6) 577	621	69	25	(10.1) 715
Nuclear and Radiation Chemistry	116	63	104	(6.1) 283	163	79	137	(6.3) 379	219	91	157	(6.6) 467
Reactor Engineering	229	277	462	(20.9) 968	278	370	704	(22.5) 1,352	344	405	779	(21.6) 1,528
Other Nuclear Engineering	223	356	459	(22.4) 1,038	276	442	634	(22.5) 1,352	365	430	769	(22.1) 1,564
Radiation Applications	85	66	30	(3.9) 181	99	81	36	(3.6) 216	137	93	25	(3.6) 255
Health Physics	55	64	1	(2.6) 120	58	74	42	(2.9) 174	70	58	28	(2.2) 156
Radiation Biology	52	67	38	(3.4) 157	90	103	47	(4.0) 240	123	108	73	(4.3) 304
Totals	1,899	1,170	1,563	4,632	2,304	1,591	2,116	6,011	2,904	1,711	2,460	7,075
Totals by time period	4,632				6,011				7,075			

CONCLUSIONS

CURRENT AND ANS PROJECT OUTPUT, BY THE EDUCATIONAL INSTITUTIONS, OF SCIENTISTS AND ENGINEERS WITH DEGREES IN NUCLEAR SCIENCE AND ENGINEERING

1) Between July 1969 and December 31, 1973, student enrollments in coursework leading to degrees in nuclear science and engineering will increase by almost 53%.
2) Percentagewise, student enrollments in radiation biology, thermonuclear physics, nuclear and radiation chemistry, reactor engineering, and other nuclear engineering disciplines show the largest increases of the 9 nuclear science and engineering disciplines listed in the survey questionnaire.
3) Between June 1969 and December 31, 1973, student enrollments in coursework leading to a BS degree in nuclear science or engineering show the greatest percentage increase (57%). Numerically, however, the largest increase is for students enrolled in PhD programs.

ANS ESTIMATES OF THE ANNUAL SUPPLY OF GRADUATING NUCLEAR SCIENTISTS AND ENGINEERS WHO WILL BE AVAILABLE TO WORK IN THE ATOMIC ENERGY FIELD

1) Slightly more than 15% of the students annually enrolled in nuclear engineering degree programs will graduate and be available from employment in the atomic energy field.
2) More than 19% of the students annually enrolled in nuclear science degree programs, or pursuing major options in nuclear science, will graduate and be available for employment in the atomic energy field.
3) During the period extending from July 1969 through December 31, 1973, 5,367 nuclear science and engineering graduates will be available for employment in the atomic energy field. Of these 5,367 graduates, 2,080 will be nuclear engineers and 3,287 will be nuclear scientists.
4) The average annual number of graduating nuclear science and engineering students who will be available for employment in the atomic energy field is 1,073

(based on 5 academic years). Of these 1,073 nuclear science and engineering graduates each year, 416 will have nuclear engineering degrees and the remaining 657 will have nuclear science degrees or major options in nuclear science.

5) Of the yearly 1,073 graduating nuclear science and engineering students who will be available for employment in the atomic energy field, 573 will have PhD's, 295 will have MS's, and 205 will have BS's.

COMPARISON OF THE EDUCATIONAL INSTITUTIONS' SUPPLY OF NUCLEAR DEGREED SCIENTISTS AND ENGINEERS AND THE DEMAND FOR THESE TYPES BY THE PRIVATE INDUSTRY, ELECTRIC UTILITIES, AND THE EDUCATIONAL INSTITUTIONS SECTORS OF THE ATOMIC ENERGY FIELD

(Refer to Tables 29 & 30 -- Pages 20 & 21)

1) The growth in requirements by the private industry, electric utilities, and educational institutions sectors of the atomic energy field for nuclear scientists and engineers between July 1969 and December 31, 1973 is about 53%. During this same time period, the growth in requirements for nuclear scientists is 46% while the growth in requirements for nuclear engineers is 62%.

2) There are more nuclear scientists and engineers graduating than there are available jobs for these types at electric utilities, educational institutions, and companies active in the private industry sector of the atomic energy field. This difference is even more pronounced for nuclear scientists with PhD's.

3) The requirements of the private industry, electric utilities, and educational institutions sectors of the atomic energy field for nuclear engineers with MS's are greater than the estimated supply of these types by the educational institutions from July 1969 through December 31, 1973.

COMP[illegible] OF THE CURRENT (1969-SIX MOS.) AND PROJECTED (1970, 1973) ANN[illegible] PPLY OF NUCLEAR OR REACTOR ENGINEERS TO THE ESTIMATED DE[illegible] FOR THESE ENGINEERING TYPES BY PRIVATE INDUSTRY, EL[illegible] C POWER UTILITIES AND EDUCATIONAL INSTITUTIONS.

(Supply data refer only to graduating nuclear or reactor engineers from schools which completed the ANS survey questionnaire and which offer degrees and/or courses in nucl[illegible]ense and engineering. Demand data do not include requirements for nuclear or reactor engineers by government-owned-contractor-operated organizations, national laboratories, defense production facilities and federal services.)

	1968 – 1969			1969 – 1970			1970 – 1971			1971 – 1972			1972 – 1973		
	PhD	MS	BS	PhD	MS	BS	PhD	MS	BS	PhD	MS	BS	PhD	MS	BS
Current and Projected Enrollments of Nuclear or Reactor Engineering Students	452	633	921	554	812	1338	605	819	1408	656	827	1478	709	835	1548
Total Number of Annual Degrees Conferred in Nuclear or Reactor Engineering[1] (Foreign)[2] (U.S. Graduates – Total)	124 – 25 99	287 – 42 245	149	152 – 31 121	369 – 54 315	217	166 – 34 132	372 – 55 317	228	180 – 37 143	375 – 55 320	239	195 – 40 155	379 – 56 323	251
Total Number of Annual Nuclear or Reactor Engineering Graduates Who Will Enroll In Advanced Degree Programs [3]	6	98	39	8	126	57	9	127	60	9	128	62	10	130	66
Total Number of Annual Nuclear or Reactor Engineering Graduates Who Will Be Drafted or Voluntarily Enlist in Military Service [4]	1	37	22	1	48	32	1	48	34	1	49	35	2	49	37
Total Number of Annual Nuclear or Reactor Engineering Foreign Graduates Who Will Return To Their Home or Third Country[5]	11	32	--	14	41	--	15	41	--	16	41	--	18	42	--
Total Number of Annual Nuclear or Reactor Engineering Graduates Who Will Be Available for Employment in the Atomic Energy Field	106	120	88	129	154	128	141	156	134	154	157	142	165	158	148
Total New Positions for Nuclear or Reactor Engineers Available at Private Industry, Electric Utilities & Educational Institutions	36	61	44	73	124	88	55	84	61	55	85	61	56	87	59
Allowances for Attrition of Nuclear or Reactor Engineers (7.6%/yr.)[6]	39	57	31	47	71	40	51	78	44	56	85	50	60	90	55
Total Annual Requirements for Nuclear or Reactor Engineers for Private Industry, Electric Utilities & Educational Institutions[7]	75	118	75	120	195	128	106	162	105	111	170	111	116	177	114
APPARENT SUPPLY-DEMAND DIFFERENCE +	31	2	13	9		--	35		29	43		31	49		34
APPARENT SUPPLY-DEMAND DIFFERENCE –					41			6			13			19	

1. The percentage of PhD graduating students to total PhD enrollments was calculated to be 27.5%; MS: 45.4%; and, BS: 16.2%.
2. The percentage of graduating foreign students to total graduates at the PhD level was calculated to be 20.4%; MS: 14.7%.
3. The percentage of graduating PhD students who will continue their education (Post-Doctoral) to the total number of graduating PhD's was calculated to be 5.2%; MS: 34.2%; and, BS: 26.1%.
4. The percentage of graduating PhD students who will be drafted or voluntarily join the military service to the total number of graduating PhD's was calculated to be 1.0%; MS: 15.2%; and, BS: 14.8%.
5. Percentages derived from A. David Rossin's Survey of Foreign Students Obtaining MS and PhD's at American Universities (1952 – 1967).
6. 7.6% rate of attrition based upon the following factors (%): Retirements and Deaths = 4.0%; Educational Updating While Employed = 2.0%; and, Turnover and Transfers = 1.6%. These factors and percentages were obtained from BLS Technical Note *(Monthly Labor Review,* November 1966.
7. Total annual requirements for nuclear or reactor engineers for the period 1968 – 1969 is calculated for a six month period ONLY.

Table 30

COMPARISON OF THE CURRENT (1969-SIX MOS.) AND PROJECTED (1970, 1973) ANNUAL SUPPLY OF NUCLEAR OF NUCLEAR SCIENTISTS TO THE ESTIMATE MAND FOR THESE SCIENTIFIC TYPES BY PRIVATE INDUSTRY, ELECTRIC POWER UTILITIES AND EDUCATIONAL INSTITUTIONS.

(Supply data refer only to graduating nuclear scientists from schools which completed the ANS survey questionnaire and which offer degrees and/or courses in nuclear science and engineering. Demand data do not include requirements for nuclear scientists by government-owned-contractor-operated organizations, national laboratories, defense production facilities and federal services.)

	1968 - 1969			1969 - 1970			1970 - 1971			1971 - 1972			1972 - 1973		
	PhD	MS	BS	PhD	MS	BS	PhD	MS	BS	PhD	MS	BS	PhD	MS	BS
Current and Projected Enrollments of Nuclear Scientists	1447	537	642	1750	779	778	1898	811	822	2046	843	867	2195	876	912
Total Number of Annual Degrees Conferred in Nuclear Science [1] (Foreign) [2] (U.S. Graduates – Total)	398 -81 317	244 -36 208	104	481 -98 383	354 -52 302	126	522 – 106 416	368 – 54 314	133 –	553 -113 440	383 – 56 327	140	604 -123 481	398 – 59 339	148
Total Number of Annual Nuclear Science Graduates Who Will Enroll in Advanced Degree Programs [3]	21	83	27	25	121	33	27	126	35	29	131	37	31	136	39
Total Number of Annual Nuclear Science Graduates Who Will Be Drafted or Voluntarily Enlist in the Military Service [4]	3	32	15	4	46	19	4	48	20	4	50	21	5	52	22
Total Number of Annual Nuclear Science Foreign Graduates Who Will Return To Their Home or Third Country [5]	36	27	--	43	39	--	47	41	--	50	42	--	54	44	--
Total Number of Annual Nuclear Science Graduates Who Will Be Available for Employment in the Atomic Energy Field	338	102	62	409	148	74	444	153	78	470	160	82	514	166	87
Total New Positions for Nuclear Scientists at Private Industry, Electric Utilities and Educational Institutions	75	30	20	152	63	42	136	59	44	137	61	45	139	62	45
Allowances for Attrition of Nuclear Scientists (8.4%) [6]	127	49	24	146	53	28	157	57	31	169	62	35	181	69	40
Total Annual Requirements for Nuclear Scientists for Private Industry, Electric Utilities and Educational Institutions [7]	202	79	44	298	116	70	293	116	75	306	123	80	320	131	95
APPARENT SUPPLY-DEMAND DIFFERENCE + –	136	23	18	111	32	4	151	37	3	164	37	2	194	35	8

1. – 5. See explanation of table concerned with nuclear or reactor engineers.

6. 8.4% rate of attrition based upon the following factors (%): Retirements and Deaths = 4.0%; Educational Updating While Employed = 2.0%; and Turnover and Transfers = 2.4%.

7. Total annual requirements for nuclear scientists for the period 1968 - 1969 is calculated for a six month period only.

CONCLUSIONS

4) *Under normal circumstances, the commission laboratories, defense production facilities, federal services, and other government-owned-contractor-operated organizations have been the primary source of employment for nuclear scientists and engineers. However, because of the large government cutbacks in both research and operational appropriations, these employment markets, at least in the near future, will no longer constitute the major employment market for nuclear scientists and engineers let alone scientists and engineers in general.*

5) *Furthermore, because of these government cutbacks, the commission laboratories have or are in the process of laying-off some of their technical employees thus placing a large number of experienced individuals in the employment market. It it these experienced individuals who will temporarily affect the employment opportunities of nuclear science and engineering graduates in the atomic energy field.*

DEMAND FOR SCIENTISTS, ENGINEERS, AND TECHNICIANS IN SELECTED SECTORS OF THE ATOMIC ENERGY FIELD

(Refer to Table 36 -- Page 24)

1) Between July 1969 and December 31, 1973, the private industry, electric utilities and educational institutions sectors of the atomic energy field will require additional technical manpower at a growth rate of about 49%.

2) For the three sectors of the atomic energy field included in the survey, requirements for technicians to fill new positions will be greater than requirements for scientists or engineers.

3) The three sectors of the atomic energy field included in the survey are generally de-emphasizing the employment of PhD's while correspondingly increasing the number of BS's they plan to hire. This situation is true whether or not the individual has his degree in nuclear science or engineering.

4) The total technical manpower requirements of the atomic energy field including those sectors of the field <u>not covered in the ANS survey</u> but for which approximate employment projections were made by the ANS for the period extending from July 1969 through December 31, 1973 are 26,078. These technical manpower estimates are for <u>new positions only.</u> Of the estimated 26,078 individuals, 11,861 will be technician-level individuals.

5) To fill not only new positions but also replacement positions, the atomic energy field will need about 67,369 scientists, engineers, and technicians between July 1969 and December 31, 1973.

Table 36

ANNUAL INCREMENTAL REQUIREMENTS FOR SCIENTISTS, ENGINEERS AND TECHNICIANS WHO WILL SPEND AT LEAST 50% OF THEIR WORKING TIME IN THE ATOMIC ENERGY FIELD: 1969 – 1973.

(Data include annual incremental requirements for scientists, engineers and technicians at private industry, electric power utilities and educational institutions based on the data these sectors of the atomic energy field provided to the American Nuclear Society. Data also include annual incremental requirements for scientists, engineers and technicians by government-owned-contractor-operated organizations, national laboratories, defense production facilities, federal services and other organizations not covered in the ANS study but for which the ANS made estimates.)

SEGEMENTS OF THE ATOMIC ENERGY FIELD	1969 (6 mo.)			1970			1971			1972			1973			TOTAL
	Scientists	Engineers	Technicians	Scientists	Engineers	Technicians	Scientists	Engineers	Technicians	Scientists	Engineers	Technicians	Scientists	Engineers	Technicians	1969-1973
Commission Laboratories	116	114	232	233	228	464	364	356	668	364	357	668	364	357	668	5,553
Commission Production Facilities	(3)	1	32	(8)	2	64	(23)	(25)	(13)	(23)	(25)	(14)	(23)	(25)	(14)	(97)
All Other GOCO	9	5	15	20	12	31	2	10	20	2	10	20	2	10	21	189
TOTAL GOCO	122	120	279	245	242	559	343	341	675	343	342	674	343	342	675	5,645
TOTAL UNIVERSITY RESEARCH AND TEACHING	61	27	(3)	124	55	(6)	146	41	49	147	41	49	147	41	49	968
Uranium Milling	(1)	2	13	(4)	6	27	5	14	4	6	15	4	6	15	5	117
Production of Feed Materials	(3)	3	7	(6)	6	15	10	12	4	11	12	4	11	13	5	104
Production of Special Materials for Use in Reactors	4	9	14	9	18	30	7	6	38	8	6	38	8	6	38	239
Fuel Element Fabrication and Recovery Activities	18	22	20	36	45	40	78	31	69	79	31	69	79	32	69	718
Reactor and Reactor Design and Manufacturing	51	136	144	103	272	289	129	475	456	129	476	456	130	476	457	4179
Design and Engineering of Nuclear Facilities	7	111	81	15	222	163	20	118	315	20	119	315	20	119	315	1960
Radioactive Waste Disposal	–	2	10	–	6	20	–	4	16	–	4	17	–	4	17	100
Nuclear Instrument Manufacturing	10	16	28	21	34	58	24	60	152	24	61	152	25	61	153	879
Processing and Packaging Radioisotopes	35	7	32	72	15	64	34	12	61	34	12	61	35	12	61	547
Particle Accelerator Manufacturing	1	9	20	2	19	41	4	18	37	4	18	37	4	18	37	269
Private Research Laboratories	39	59	59	77	117	117	69	79	84	69	79	84	69	79	84	1,164
Industrial Radiography	–	3	25	–	6	52	2	5	32	3	5	32	3	5	32	205
Miscellaneous	2	6	8	3	12	16	3	11	15	3	12	16	3	12	16	138
TOTAL PRIVATE ESTABLISHMENTS	163	385	461	328	778	932	385	845	1,283	390	850	1,285	393	852	1,289	10,619
TOTAL ELECTRIC POWER UTILITIES	10	203	242	21	407	484	11	203	230	11	204	230	11	204	230	2,701
TOTAL OTHER	130	197	183	262	396	366	355	636	549	355	637	549	355	637	550	6,157
GRAND TOTALS	486	932	1,162	980	1,878	2,335	1,240	2,066	2,786	1,246	2,074	2,787	1,249	2,076	2,793	26,090
ALLOWANCE FOR ATTRITION	874	1,133	1,879	1,871	2,482	4,142	1,975	2,639	4,449	2,080	2,797	4,756	2,184	2,955	5,063	41,279
TOTAL YEARLY REQUIREMENTS FOR SCIENTISTS, ENGINEERS & TECH.	1,360	2,065	3,041	2,851	4,360	6,477	3,215	4,705	7,235	3,326	4,871	7,543	3,433	5,031	7,856	67,369

TECHNICAL MANPOWER REQUIREMENTS OF SELECTED PRIVATE INDUSTRIES ACTIVE IN THE ATOMIC ENERGY FIELD

RELATING THE RESULTS OF THE ANS SURVEY TO THE HISTORICAL DATA PROVIDED BY THE BUREAU OF LABOR STATISTICS' "ANNUAL SURVEY OF SCIENTIFIC AND TECHNICAL EMPLOYMENT IN THE ATOMIC ENERGY FIELD"

Since the BLS "Annual Survey of Employment in the Atomic Energy Field" provides the largest set of historical data available on employment in the atomic energy field, at attempt was made to relate the results of the ANS survey to that data. Within each economic or functional segment (as defined by the Bureau of Labor Statistics - BLS), an attempt was made to select representative large, medium, and small-sized companies with a total number of technical employees of at least 50% of the total number of technical employees reported by all privately owned companies in the 1967 BLS survey. A total of 68 organizations were interviewed (70 companies were contacted). Nine of these 68 organizations are electric power utilities that have or are planning to have a nuclear power plant in operation by 1976. The results of these 9 interviews are presented in the section of this report entitled "Technical Manpower Requirements of the Electric Power Utilities." Of the remaining 59 companies, 5 organizations were interviewed which were not in the 1967 BLS survey. These 5 companies were chosen because of their future growth potential in the atomic energy field as evaluated by the staff of the American Nuclear Society. Therefore, the data to be reported in this section were based on a sample of 54 companies active in the private sector of the atomic energy field.

Data presented in this section of the report represent the results of the extrapolations, on a segment-by-segment basis, of the data provided by the sample companies to the total universe (the total number of companies reporting to the annual BLS survey). The extrapolations were based on a weighed average of the percentage of the total number of scientists, engineers, and technicians reported

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ANS SURVEY TO BLS STATISTICS

by the sample companies to the BLS to the total number of scientists, engineers and technicians reported to the BLS by all companies responding to the 1966, 1967, and 1968 BLS surveys.

Neither the data collection activities nor statistical extrapolations were made for the BLS segment entitled "Power Reactor Operations and Maintenance." This segment was covered as a separate ANS study because: the current and projected manpower requirements for all electric power utilities that have or are planning to have a nuclear power plant in operation by 1977 was obtained from the more recently completed Rossin-Voigt study.

The ANS did, however, conduct a total of 9 in-depth interviews with a select sample of electric power utilities. For these 9 interviews, only the qualitative questions of the in-depth interview were asked and the summation of these interviews is presented in the section of this report entitled "Technical Manpower Requirements of the Electric Power Utilities."

When the ANS attempted to tie its data into the historical BLS data, the resulting ANS 1969 data were, in total, only 1.1% greater than the 1969 data recently released by the BLS. Significant variations, however, appeared in certain categories as can be seen from the following comparison:

1969 TECHNICAL MANPOWER IN SELECTED SEGMENTS
OF THE ATOMIC ENERGY FIELD - PRIVATE SECTOR ONLY

Category	ANS Extrapolated Data	BLS Data	ANS/BLS Difference	% Difference
Scientists	3,953	2,475	+1,478 (ANS)	37.4%
Engineers	9,831	11,293	+1,462 (BLS)	12.9%
Technicians	10,522	10,278	+ 244 (ANS)	2.3%
TOTALS	24,306	24,046	+ 260 (ANS)	1.1%

RELATING THE RESULTS OF THE
ANS SURVEY TO BLS STATISTICS

The magnitude of the differences between the two reports varies between segments (i.e., Uranium Milling) and, within each segment, between the number of scientists, engineers, and technicians. However, it is interesting to note how close the two surveys are in their overall totals.

The differences between the 1969 ANS projected data and the 1969 BLS actual reported data can perhaps best be explained by the fact that the individuals interviewed by the ANS were probably not the ones who would ordinarily have completed the BLS questionnaire and therefore there was some difference in interpretation of definitions and segments used in the surveys. These differences in numbers are not considered significant insofar as the accuracy of the ANS survey is concerned. What the reader should direct his attention to is the identification of the general trends in future technical manpower requirements of the atomic energy field.

PRESENTATION OF STATISTICAL DATA FOR PRIVATE INDUSTRY'S
MANPOWER REQUIREMENTS (EXCLUDING ELECTRIC UTILITIES)

The data, extrapolated from the sample companies to the entire universe (private sector) for 1969, 1970, and 1973, are presented in Table 1. (The manpower data represents only those employees who spend at least 50% of their working time in atomic energy activities.) Subtotal data are presented for each of 13 occupational categories. The overall ANS projected growth of manpower in the private sector of the atomic energy field between July 1969 and December 31, 1973 is 43.6%.

Percentage increases projected by ANS between July 1969 and December 31, 1973 for each of the listed occupational categories are:

STATISTICAL MANPOWER REQUIREMENTS
DATS FOR PRIVATE INDUSTRY

Occupational Categories	% Increase Between July 1969 and December 31, 1973 (1)	Numerical Increase Between July 1969 and December 31, 1973
Nuclear Materials Managers	101.8%	57
Health Physics Technicians & Radiation Monitors	79.0%	364
Life Scientists	78.6%	309
Life Science Technicians	78.6%	114
Draftsmen	61.7%	1,896
Physical Science Technicians	47.9%	758
Electrical/Electronics Technicians	45.6%	737
Mathematicians	42.4%	179
Other Technicians	40.0%	505
Engineers	37.7%	3,704
Physical Scientists	37.2%	1,167
Other Engineering Technicians	35.9%	751
Nuclear Reactor Operators	28.2%	66
TOTALS	43.6%	10,607

(1) Percentage increases throughout the report are based on a 4½ year time period (July 1969 - December 31, 1973).

Although engineers and physical scientists rank first and third with the numerically largest increases, they rank only tenth and eleventh in terms of percentage increase between 1969 and 1973. It is interesting to note that 3 of the top 4 occupational categories, ranked by percent increase, are related to the life sciences. The significance of this finding is probably related to the increased awareness, on the part of private industry, of radiation safety, thermo-pollution and other environmental considerations.

Table 1

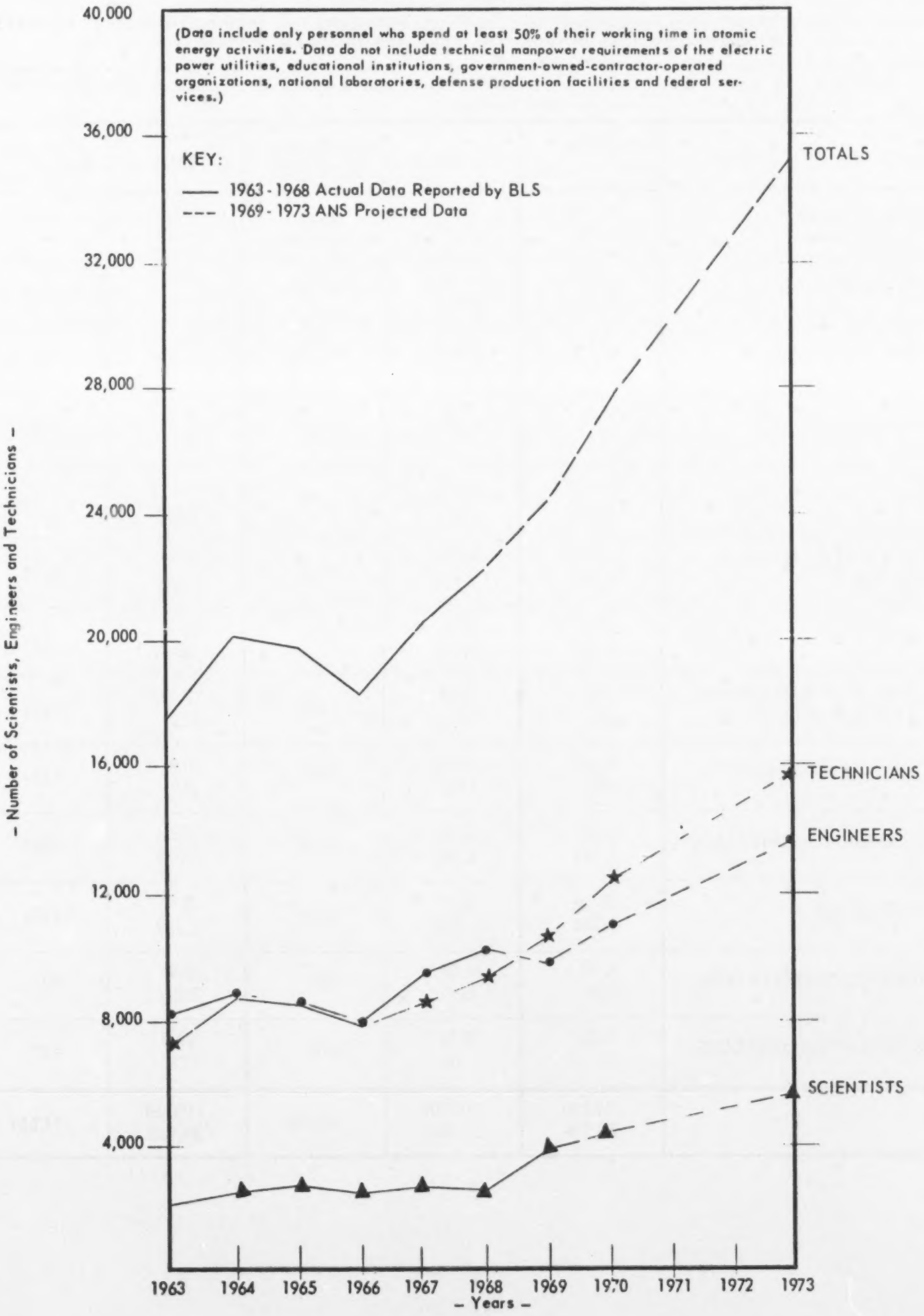
PRIVATE INDUSTRY'S CURRENT (1969) EMPLOYMENT OF SCIENTISTS, ENGINEERS AND TECHNICIANS BY OCCUPATIONAL CATEGORIES AND ANS PROJECTIONS OF TECHNICAL MANPOWER REQUIREMENTS FOR 1970 AND 1973.

(Data include only personnel who spend at least 50% of their working time in atomic energy activities. Data do not include technical manpower requirements of the electric power utilities, educational institutions, government-owned-contractor-operated organizations, national laboratories, defense production facilities and federal services.)

OCCUPATIONAL CATEGORIES	CURRENT EMPLOYMENT	1970	INCREASE/ DECREASE	1973	INCREASE/ DECREASE
PHYSICAL SCIENTISTS	(12.9) 3,138	(12.7) 3,478	+340	(12.3) 4,305	+827
LIFE SCIENTISTS	(1.6) 393	(1.8) 494	+101	(2.0) 702	+208
ENGINEERS	(40.4) 9,831	(40.2) 10,995	+1,164	(38.8) 13,535	+2,540
MATHEMATICIANS	(1.7) 422	(1.7) 472	+50	(1.7) 601	+129
DRAFTSMEN	(12.7) 3,074	(13.2) 3,607	+533	(14.2) 4,970	+1,363
ELECTRICAL & ELECTRONICS TECHNICIANS	(6.7) 1,617	(6.5) 1,779	+162	(6.7) 2,354	+575
OTHER ENGINEERING TECHNICIANS	(8.6) 2,090	(8.0) 2,207	+117	(8.1) 2,841	+634
HEALTH PHYSICS TECHNICIANS & RADIATION MONITORS	(1.9) 461	(2.2) 591	+130	(2.4) 825	+234
LIFE SCIENCE TECHNICIANS	(0.6) 145	(0.7) 192	+47	(0.8) 259	+67
PHYSICAL SCIENCE TECHNICIANS	(6.5) 1,581	(6.5) 1,782	+201	(6.7) 2,339	+557
OTHER TECHNICIANS	(5.2) 1,264	(5.2) 1,415	+151	(5.1) 1,769	+354
NUCLEAR REACTOR OPERATORS	(1.0) 234	(1.0) 266	+32	(0.9) 300	+34
NUCLEAR MATERIALS MANAGERS	(0.2) 56	(0.3) 76	+20	(0.3) 113	+37
TOTALS	(100.0) 24,306	(100.0) 27,354	+3,048	(100.0) 34,913	+7,559

Chart 1

EMPLOYMENT OF SCIENTISTS, ENGINEERS AND TECHNICIANS BY PRIVATE INDUSTRY FOR EACH YEAR EXTENDING FROM 1963 THROUGH 1968 (AS REPORTED BY THE BUREAU OF LABOR STATISTICS) AND ANS PROJECTIONS OF THE TECHNICAL MANPOWER REQUIREMENTS OF PRIVATE INDUSTRY FOR 1969, 1970 AND 1973.



STATISTICAL MANPOWER REQUIREMENTS
DATS FOR PRIVATE INDUSTRY

The percent increases projected by ANS between July 1969 and December 31, 1973 for occupational categories consolidated into 3 broad categories of scientists, engineers, and technicians are:

Occupational Categories	% Increase Between July 1969 and December 31, 1973	Numerical Increase Between July 1969 and December 31, 1973
Technicians (includes draftsmen, nuclear reactor operators and nuclear materials managers)	49.9%	5,248
Scientists (includes mathematicians	41.9%	1,655
Engineers	37.7%	3,704

Chart 1 represents the actual historical BLS technical manpower data (1963-1968) for selected segments of the atomic energy field (electric utilities excluded) and ANS projections of technical manpower requirements through 1973. Although each of the 3 categories shows an increase between 1969 and 1973, requirements for technicians will be greater than for engineers. This has not been historically true and the change may reflect the transition of the atomic energy field from an orientation of research and development to product development. If such a transition is taking place, one would not expect to see such a large increase in scientists. However, with the increased concern over environmental its technical capability with a view to solving these problems.

Table 2 shows the number of currently (1969) employed scientists and engineers who have degrees in nuclear science and engineering and the requirements of private industry for these types in 1970 and 1973 as determined by the ANS survey. Private industry's requirements for scientists with nuclear degrees will increase by 62.5% between July 1969 and December 31, 1973. Approximately 95 nuclear scientists will be needed each year to fill new positions. Requirements for nuclear engineers will increase by 57.5% during the same period. About 129

nuclear engineers will be needed to fill new positions each year.

The breakdown of all currently (1969) employed scientists and engineers by educational background, is presented in Chart 2. Percentages of currently employed scientists and engineers with a particular educational background to the total number of currently employed scientists and engineers are as follows:

Educational Background	% of Currently Employed Scientists or Engineers	Number of Currently Employed Scientists or Engineers
Mechanical Engineering	28.2%	3,775
Electrical/Electronics Engineering	13.2%	1,772
Physics	9.2%	1,223
Nuclear Engineering	9.0%	1,196
Chemical Engineering	8.8%	1,170
Chemistry	7.9%	1,054
Other Engineering Disciplines	6.0%	800
Metallurgical Engineering	4.5%	598
Civil Engineering	3.5%	466
Metallurgy	2.5%	338
Nuclear Physics	2.0%	267
Other Sciences	2.0%	265
Biology	0.9%	120
Nuclear and Radiation Chemistry	0.7%	93
Geology & Geophysics	0.6%	86
Health Physics	0.6%	84
Other Nuclear Degrees	0.2%	32
High Energy Phsycis	0.2%	23
TOTALS	100.0%	13,362

STATISTICAL MANPOWER REQUIREMENTS
DATA FOR PRIVATE INDUSTRY

Scientists and engineers with nuclear science and engineering degrees comprise 12.7% (1,195) of the total number of currently employed scientists and engineers. (The cover of this report presents a graphic representation of the distribution of the currently employed scientists and engineers working in the private sector of the atomic energy field by educational backgrounds.)

Chart 3 shows the breakdown of the currently employed scientists and engineers by level of degree, for both degreed (non-nuclear) and nuclear degreed personnel. Of the currently employed nuclear degreed scientists and engineers, 21.9% have BS's; 53.4% have MS's; and, 24.7% have PhD's. Of the other degreed (non-nuclear) personnel currently employed by private industry, 68.1% have BS's; 23.4% have MS's; and, 8.5% have PhD's. For nuclear degreed scientists and engineers, the companies seem to prefer MS-level graduates while for the other degreed (non-nuclear) scientists and engineers the preference apparently is for BS-level graduates.

There is a difference of 147 people between the total number of degreed personnel (13,215) and the total number of scientists and engineers listed by educational backgrounds (13,362). This disparity is due to the fact that these 147 individuals do not have college degrees but, based on their training and experience, are considered to be equivalent to degreed personnel. Therefore, of the total staff of scientists and engineers currently employed by private industry, 1.1% do not have academic degrees but through training and experience are assigned job responsibilities equivalent to degreed individuals.

The annual requirements by private industry for nuclear degreed scientists and engineers between July 1969 and December 31, 1973 to fill new positions are:

Table 2

PRIVATE INDUSTRY'S CURRENT (1969) EMPLOYMENT OF SCIENTISTS AND ENGINEERS WITH DEGREES IN NUCLEAR SCIENCE AND ENGINEERING AND ANS PROJECTIONS OF REQUIREMENTS FOR THESE TECHNICAL PERSONNEL FOR 1970 AND 1973.

(Data include only personnel who spend at least 50% of their working time in atomic energy activities. Data do not include technical manpower requirements of the electric power utilities, educational institutions, government-owned-contractor-operated organizations, national laboratories, defense production facilities and federal services.)

OCCUPATIONAL CATEGORIES	CURRENT EMPLOYMENT	1970	INCREASE/ DECREASE	1973	INCREASE/ DECREASE
SCIENTISTS (Life & Physical)	(40.2) 682	(40.5) 835	+153	(40.1) 1,108	+273
ENGINEERS	(59.8) 1,013	(59.5) 1,229	+216	(59.0) 1,595	+366
TOTALS	(100.0) 1,695	(100.0) 2,064	369	(100.0) 2,703	+639

Chart 2

BREAKDOWN OF SCIENTISTS AND ENGINEERS, BY EDUCATIONAL BACKGROUND, CURRENTLY (1969) EMPLOYED BY PRIVATE INDUSTRY.

(Data include only scientists and engineers who spend at least 50% of their working time in atomic energy activities. Data do not include scientists and engineers currently (1969) employed at the electric power utilities, educational institutions, government-owned-contractor-operated organizations, national laboratories, defense production facilities and federal services.)

KEY:

- Scientists & Engineers With Degrees In Nuclear Science and Engineering (1969 = 1,695 Total)
- Scientists & Engineers With Degrees In Disciplines Other Than Nuclear Science and Engineering (1969 = 11,667 Total)

– Number of Scientists and Engineers –

4,000
3,500
3,000
2,500
2,000
1,500
1,000
500

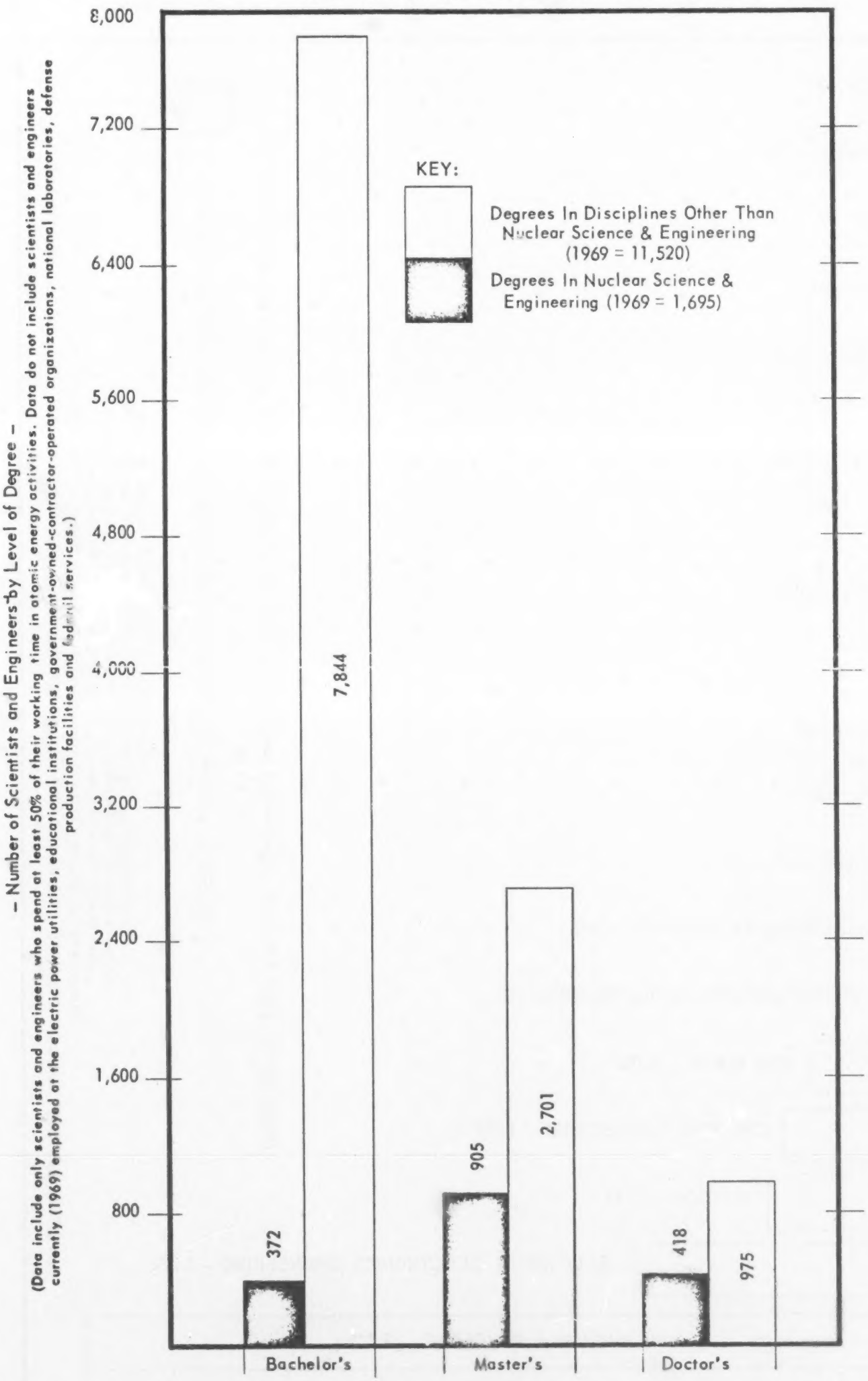
HIGH ENERGY PHYSICS – 23
OTHER NUCLEAR DEGREES – 32
HEALTH PHYSICS – 84
NUCLEAR CHEMISTRY – 93
NUCLEAR PHYSICS – 267
NUCLEAR OR REACTOR ENGINEERING – 1,196
GEOLOGY & GEOPHYSICS – 86
BIOLOGY – 120
OTHER SCIENCES – 265
METALLURGY – 338
CIVIL ENGINEERING – 466
METALLURGICAL ENGINEERING – 598
OTHER ENGINEERING DISCIPLINES – 800
CHEMISTRY – 1,054
CHEMICAL ENGINEERING – 1,170
PHYSICS – 1,223
ELECTRICAL/ELECTRONICS ENGINEERING – 1,772
MECHANICAL ENGINEERING – 3,775

– Science or Engineering Disciplines –

55

Chart 3

BREAKDOWN OF NUCLEAR-DEGREE AND DEGREE (NON-NUCLEAR) SCIENTISTS AND ENGINEERS, BY LEVEL OF DEGREE, CURRENTLY (1969) EMPLOYED BY PRIVATE INDUSTRY.


8,000
7,200
6,400
5,600
4,800
4,000
3,200
2,400
1,600
800
KEY:
Degrees In Disciplines Other Than Nuclear Science & Engineering (1969 = 11,520)
Degrees In Nuclear Science & Engineering (1969 = 1,695)
372
7,844
905
2,701
418
975
Bachelor's
Master's
Doctor's
– Number of Scientists and Engineers by Level of Degree –
(Data include only scientists and engineers who spend at least 50% of their working time in atomic energy activities. Data do not include scientists and engineers currently (1969) employed at the electric power utilities, educational institutions, government-owned-contractor-operated organizations, national laboratories, defense production facilities and federal services.)

STATISTICAL MANPOWER REQUIREMENTS
DATA FOR PRIVATE INDUSTRY

ANNUAL INCREMENTAL REQUIREMENTS FOR NUCLEAR DEGREED
PERSONNEL TO FILL NEW POSITIONS

Year	Scientists	Engineers
1969 (6 mo.)	51	72
1970	102	144
1971	91	122
1972	91	122
1973	91	122

To arrive at the total technical manpower requirements of private industry for nuclear degreed personnel, allowances for attrition must be included in addition to requirements to fill new positions. (Allowances for attrition to be used throughout this report are: 8.4% for scientists and 7.6% for engineers.)(2)

	Nuclear Scientists			Nuclear Engineers		
Year	Growth	Replacement	Total	Growth	Replacement	Total
1969 (6 mo.)	51	57	108	72	77	149
1970	102	70	172	144	93	237
1971	91	77	168	122	102	224
1972	91	85	176	122	111	233
1973	91	93	184	122	121	243
TOTALS	426	382	808	582	504	1,086
Average Annual Incremental Requirements (4½ yrs.)	94.7	84.9	179.6	129.3	112.0	241.3

Between July 1969 and December 31, 1973, a total of 1,894 nuclear degreed personnel will be required by the private sector of the atomic energy field for new and replacement positions. This total requirement averages out to an annual need of about 421 nuclear degreed scientists and engineers.

(2) "Projections of Manpower Supply in a Specific Occupation," Neal Rosentham, Monthly Labor Review, Nov. 1966, U.S. Dept. of Labor, Bureau of Statistics

STATISTICAL MANPOWER REQUIREMENTS
DATA FOR PRIVATE INDUSTRY

Further statistical analyses and the summation of the in-depth interviews will be covered for each of the 13 functional segments of the private sector of the atomic energy field. The "Power Reactor Operations and Maintenance" segment will be described in the section of this report entitled "Technical Manpower Requirements of the Electric Power Utilities."

URANIUM MILLING

BLS Segment Definition -- Reduction of uranium ores to concentrates for further processing as feed materials

PRESENTATION OF STATISTICAL DATA

In 1968, the interviewed companies employed 16.4% of all engineers, 35.9% of all scientists and 28.0% of all technicians working in the uranium milling segment as reported by the BLS. The historical BLS data for scientists, engineers and technicians working in the uranium milling segment are given below:

Historical BLS Data (1963 - 1968)

Year	Scientists	Engineers	Technicians	Totals
1963	49	169	138	356
1964	27	133	113	273
1965	26	129	105	260
1966	22	146	129	297
1967	82	134	136	352
1968	64	61	82	207

Data provided by the sample companies and extrapolated by the ANS to the entire uranium milling segment for 1969, 1970 and 1973 are presented in Table 3. The overall growth of technical manpower requirements for the uranium milling segment of the atomic energy field, between July 1969 and December 31, 1973, is 26.3%.

The percent increases between July 1969 and December 31, 1973 for each of the listed occupational categories are:

Occupational Categories	% Increase Between July 1969 and December 31, 1973	Numerical Increase Between July 1969 and December 31, 1973
Life Scientists	500.0%	10
Health Physics Technicians & Radiation Monitors	182.4%	31

Table 3

– URANIUM MILLING –

CURRENT (1969) EMPLOYMENT OF SCIENTISTS, ENGINEERS AND TECHNICIANS BY OCCUPATIONAL CATEGORIES AND ANS PROJECTIONS OF TECHNICAL MANPOWER REQUIREMENTS FOR 1970 AND 1973.

(Data include only personnel employed by privately-owned companies active in uranium milling who spend at least 50% of their working time in atomic energy activities.)

OCCUPATIONAL CATEGORIES	CURRENT EMPLOYMENT	1970	INCREASE/ DECREASE	1973	INCREASE/ DECREASE
PHYSICAL SCIENTISTS	77	72	-5	79	+7
LIFE SCIENTISTS	2	2	–	12	+10
ENGINEERS	236	244	+8	282	+38
DRAFTSMEN	30	35	+5	30	-5
ELECTRICAL & ELECTRONICS TECHNICIANS	4	4	–	4	–
HEALTH PHYSICS TECHNICIANS & RADIATION MONITORS	17	30	+13	48	+18
PHYSICAL SCIENCE TECHNICIANS	56	78	+22	78	–
TOTALS	422	465	+43	533	+68

(Cont'd) Occupational Categories	% Increase Between July 1969 and December 31, 1973	Numerical Increase Between July 1969 and December 31, 1973
Physical Science Technicians	39.3%	22
Engineers	19.5%	46
Physical Scientists	2.6%	2
Draftsmen	0.0%	--
Electrical/Electronics Technicians	0.0%	--
TOTALS	26.3%	111

Consolidating the above occupational categories into three broad categories of scientists, engineers, and technicians, this breakdown shows the following percent increases between July 1969 and December 31, 1973:

Occupational Categories	% Increase Between July 1969 and December 31, 1973	Numerical Increase Between July 1969 and December 31, 1973
Technicians (Includes Draftsmen)	49.5%	53
Engineers	19.5%	46
Scientists	15.2%	12

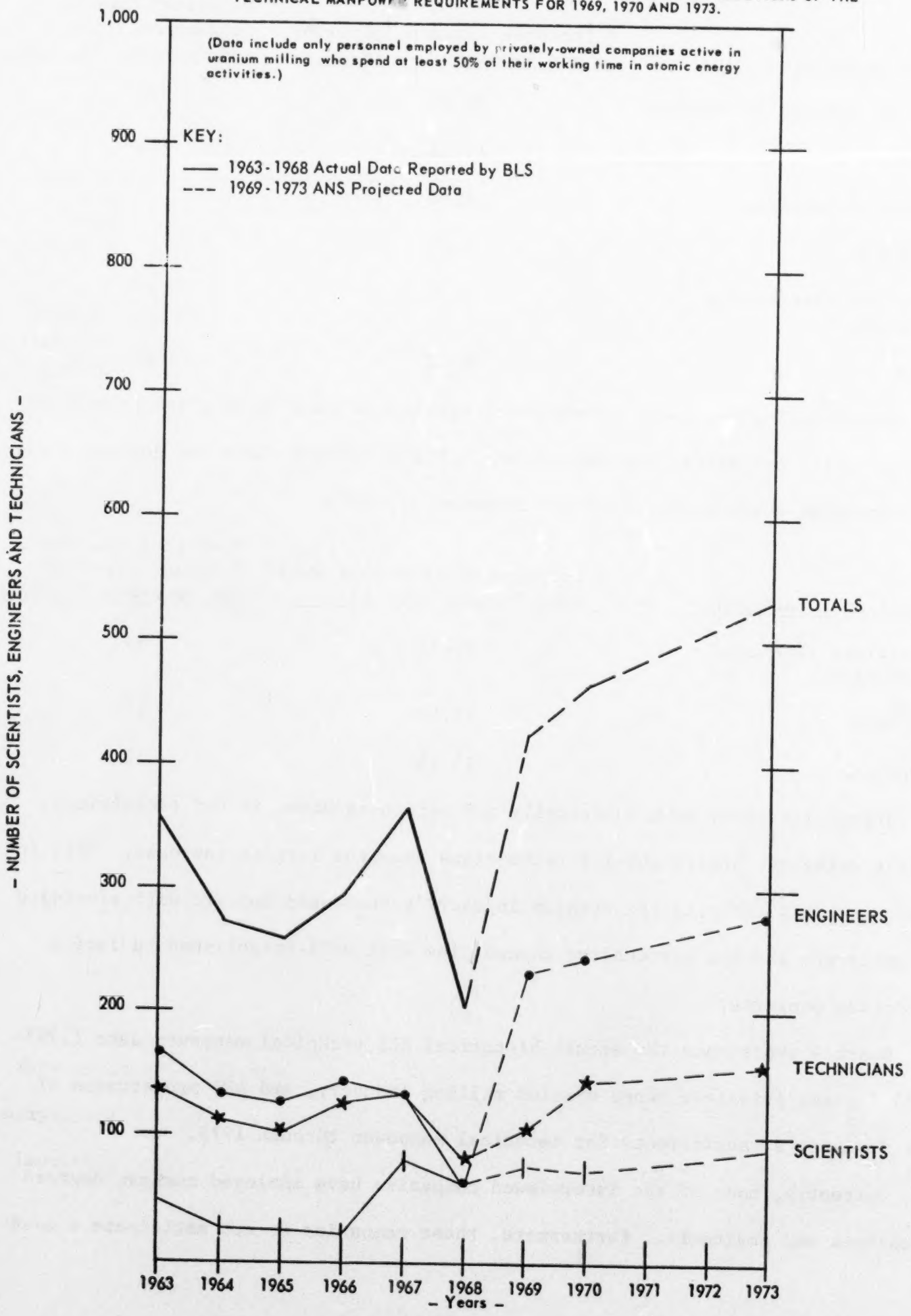
The largest increase, both numerically and percentagewise, is for technicians. In this category, health physics technicians show the largest increase. This increase probably reflects the uranium industry's increased concern with providing its employees and the surrounding communities with well-established radiation protection programs.

Chart 4 represents the actual historical BLS technical manpower data (1963-1968) for the privately owned uranium milling industry, and ANS projections of this industry's requirements for technical manpower through 1973.

Currently, none of the interviewed companies have employed nuclear degreed scientists and engineers. Furthermore, these companies do not anticipate a need

Chart 4

EMPLOYMENT OF SCIENTISTS, ENGINEERS AND TECHNICIANS BY COMPANIES ACTIVE IN THE URANIUM MILLING SEGMENT OF THE PRIVATE SECTOR OF THE ATOMIC ENERGY FIELD FOR EACH YEAR EXTENDING FROM 1963 THROUGH 1968 (AS REPORTED BY THE BUREAU OF LABOR STATISTICS) AND ANS PROJECTIONS OF THE TECHNICAL MANPOWER REQUIREMENTS FOR 1969, 1970 AND 1973.



for nuclear degreed personnel in 1970, although one of the interviewed companies indicated an interest in hiring a nuclear scientist by 1973. ANS extrapolations of the data from the sample companies to the total uranium milling industry results in a requirement of only 2 nuclear scientists by 1973.

Percentages of currently employed scientists and engineers with a particular educational background to the total number of scientists and engineers currently employed in the uranium milling segment are:

Educational Background	% of Currently Employed Scientists or Engineers	Number of Currently Employed Scientists or Engineers
Mechanical Engineering	20.6%	65
Chemistry	19.0%	60
Chemical Engineering	17.5%	55
Geology & Geophysics	15.9%	50
Other Engineering Disciplines	14.3%	45
Metallurgical Engineering	6.3%	20
Physics	3.2%	10
Electrical/Electronics Engineering	1.6%	5
Biology	1.6%	5
TOTALS	100.0%	315

Of the currently employed scientists and engineers, 81.0% have BS's; 14.3% have MS's; and 4.7% have PhD's.

SUMMATION OF IN-DEPTH INTERVIEWS

The majority of degreed personnel employed at the interviewed companies work in test and evaluation, production, and management activities. Some of the degreed people are assigned to mining exploration activities. Technician level personnel work primarily in test and evaluation activities.

When these companies hire degreed technical personnel, their primary evaluation is the candidate's work experience. These companies have had no difficulty in filling their needs for degreed personnel during the past five years and they do not expect any difficulty in the near future. Likewise, the companies have been successful in hiring technicians although they foresee a shortage of technicians in the future.

Although many factors go into their manpower planning activities, "historical manpower data" and "dollar value of shipments" have been the two most reliable measures of their technical manpower requirements.

The companies believe their degreed (non-nuclear) personnel would benefit from coursework in nuclear science and engineering (i.e., reactor fuel technology, reactor materials, nuclear chemistry, health physics, and radiation safety). However, advanced coursework in chemistry, metallurgy, and metallurgical engineering would have a more practical application.

The interviewed companies expect the uranium milling business to level off during the next three years, followed by a sharp increase during the midseventies.

PRODUCTION OF FEED MATERIALS

BLS Segment Definition -- Converting uranium concentrates and ores to metal; refining and preparing oxides, florides, carbides, etc.; also uranium U-235 enrichment. Includes the recovery of scrap from the above processes.

PRESENTATION OF STATISTICAL DATA

This segment of the atomic energy field is primarily composed of government-owned establishments (about 90% of all companies reporting in this segment in the 1968 BLS survey were government-owned establishments) and, therefore, the extrapolation of the data could be made only from the data reported by the privately owned organizations. In presenting the historical BLS manpower data, only the technical employment data for the nongovernment-owned establishments will be made.

In 1968, the sample represented 45.6% of all engineers, 26.1% of all scientists, and 16.7% of all technicians working in the production of feed materials segment (privately owned companies) as reported to the BLS in 1968. The historically adjusted BLS data for scientists, engineers, and technicians working in the private sector of this segment of the atomic energy field are given below:

Historical BLS Data (1963-1968)*

Year	Scientists	Engineers	Technicians	Totals
1963	36	44	47	127
1964	36	44	46	126
1965	35	44	45	124
1966	39	45	52	136
1967	41	49	56	146
1968	46	57	60	163

* Data is only for nongovernment owned establishments.

The sample data was extrapolated by the ANS to the entire production of feed materials segment (privately owned) for 1969, 1970, and 1973. The results are

Table 4

– PRODUCTION OF FEED MATERIALS –

CURRENT (1969) EMPLOYMENT OF SCIENTISTS, ENGINEERS AND TECHNICIANS BY OCCUPATIONAL CATEGORIES AND ANS PROJECTIONS OF TECHNICAL MANPOWER REQUIREMENTS FOR 1970 AND 1973.

(Data include only personnel employed by privately-owned companies active in production of feed materials who spend at least 50% of their working time in atomic energy activities.)

OCCUPATIONAL CATEGORIES	CURRENT EMPLOYMENT	1970	INCREASE/ DECREASE	1973	INCREASE/ DECREASE
PHYSICAL SCIENTISTS	27	18	-9	28	+10
LIFE SCIENTISTS	–	–	–	14	+14
ENGINEERS	77	86	+9	123	+37
MATHEMATICIANS	5	5	–	13	+8
DRAFTSMEN	9	19	+10	28	+9
HEALTH PHYSICS TECHNICIANS & RADIATION MONITORS	–	6	+6	10	+4
LIFE SCIENCE TECHNICIANS	73	79	+6	79	–
TOTALS	**191**	**213**	**+22**	**295**	**+82**

presented in Table 4. The overall growth in technical manpower requirements for this segment between July 1969 and December 31, 1973 is 54.5%.

The percent increases between July 1969 and December 31, 1973 for each of the listed occupational categories are:

Occupational Categories	% Increase Between July 1969 and December 31, 1973	Numerical Increase Between July 1969 and December 31, 1973
Draftsmen	211.1%	19
Mathematicians	160.0%	8
Engineers	59.7%	46
Life Science Technicians	8.2%	6
Physical Scientists	3.7%	1
Life Scientists	---	14
Health Physics Technicians & Radiation Monitors	---	10
TOTALS	54.5%	104

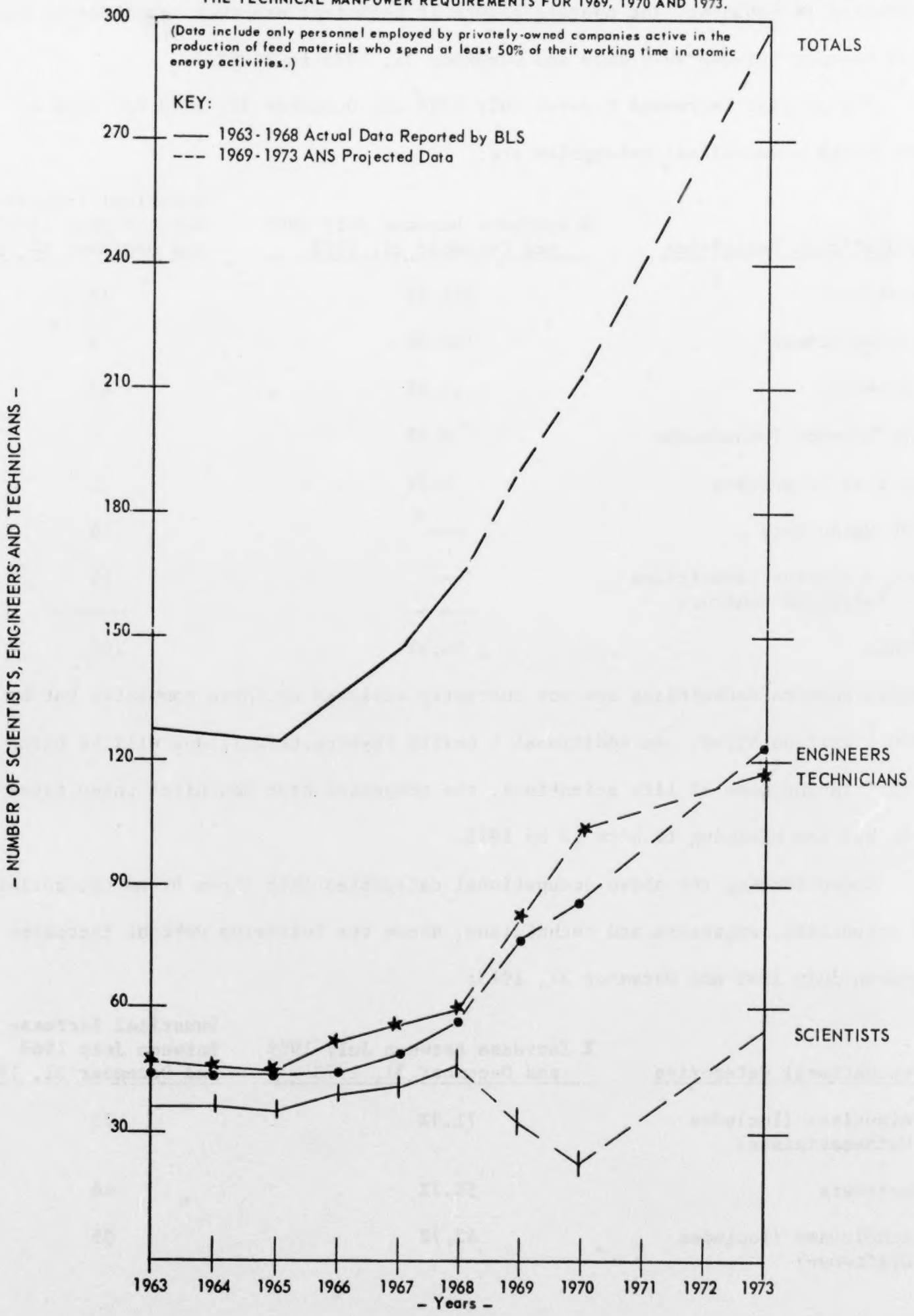
Health physics technicians are not currently employed at these companies but by 1970 6 will be hired. An additional 4 health physics technicians will be hired by 1973. In the case of life scientists, the companies have not hired these types to date but are planning to hire 14 by 1973.

Consolidating the above occupational categories into three broad categories of scientists, engineers, and technicians, shows the following percent increases between July 1969 and December 31, 1973:

Occupational Categories	% Increase Between July 1969 and December 31, 1973	Numerical Increase Between July 1969 and December 31, 1973
Scientists (Includes Mathematicians)	71.9%	23
Engineers	59.7%	46
Technicians (Includes Draftsmen)	42.7%	35

Chart 5

EMPLOYMENT OF SCIENTISTS, ENGINEERS AND TECHNICIANS BY COMPANIES ACTIVE IN THE PRODUCTION OF FEED MATERIALS SEGMENT OF THE PRIVATE SECTOR OF THE ATOMIC ENERGY FIELD FOR EACH YEAR EXTENDING FROM 1963 THROUGH 1968 (AS REPORTED BY THE BUREAU OF LABOR STATISTICS) AND ANS PROJECTIONS OF THE TECHNICAL MANPOWER REQUIREMENTS FOR 1969, 1970 AND 1973.



The scientist category shows the largest increase percentagewise, despite the fact that between 1969 and 1970, nine physical scientists will be lost. Chart 5 represents the actual historical BLS technical manpower data (1963-1968) for the entire non-government-owned companies active in the production of feed materials segment and ANS projections of this segment's requirements for technical personnel through 1973.

The past, present, and future total employment of engineers and technicians roughly parallel each other while projections for scientists in 1969 and 1970 show a significant drop. Between 1970 and 1973, the scientist category increases to a point greater than their actual number in 1968.

Currently, there are 4 nuclear scientists employed by the privately owned companies active in the production of feed materials segment. The requirements for nuclear degreed scientists will increase by 260.0% between 1969 and 1973. Approximately 3 nuclear scientists will be needed each year to fill new positions. Although these companies do no, at the present time, employ nuclear engineers, they are planning to hire 3 by 1970 and an additional 8 by 1973.

Percentages of currently employed scientists and engineers with a particular educational background to the total number of currently employed scientists and engineers are as follows:

Educational Backgrounds	% of Currently Employed Scientists and Engineers	Number of Currently Employed Scientists and Engineers
Chemistry	25.9%	27
Chemical Engineering	20.2%	21
Mechanical Engineering	17.3%	18
Metallurgical Engineering	8.7%	9
Electrical/Electronics Engineering	7.7%	8

(Cont'd) Educational Backgrounds	% of Currently Employed Scientists and Engineers	Number of Currently Employed Scientists and Engineers
Physics	6.7%	7
Other Engineering Disciplines	5.8%	6
Nuclear Chemistry	4.8%	5
Metallurgy	2.9%	3
TOTALS	100.0%	104

Of the 5 currently employed nuclear chemists, 2 have BS's; 2 have MS's; and, 1 has a PhD. Of the other degreed (non-nuclear) personnel, 74.1% have BS's; 19.0% have MS's; and, 6.9% have PhD's.

Annual requirements for nuclear degreed scientists and engineers between July 1969 and December 31, 1973 to fill new positions are:

ANNUAL INCREMENTAL REQUIREMENTS FOR NUCLEAR DEGREED PERSONNEL TO FILL NEW POSITIONS

Year	Scientists	Engineers
1969 (6 mo.)	0	1
1970	0	2
1971	4	2
1972	4	3
1973	5	3

Allowances for attrition must be included with this segment's need for scientists and engineers to fill new positions to arrive at the total technical manpower requirements for nuclear degreed personnel. (Allowances for attrition are the same as those used previously in this report: 8.4% for scientists and 7.6% for engineers.)

PRODUCTION OF FEED MATERIALS

Year	Nuclear Scientists			Nuclear Engineers		
	Growth	Replacement	Total	Growth	Replacement	Total
1969 (6 mo.)	0	0	0	1	0	1
1970	0	0	0	2	0	2
1971	4	0	4	2	0	2
1972	4	1	5	3	0	3
1973	5	2	7	3	1	4
TOTALS	13	3	16	11	1	12
Average Annual Incremental Requirements (4½ yrs.)	2.9	0.7	3.6	2.4	0.2	2.6

Between July 1969 and December 31, 1973, a total of 28 nuclear degreed personnel will be needed by the privately owned companies active in the production of feed materials segment. This requirement averages out to be about 6 nuclear degreed personnel each year to fill new and replacement positions within these companies.

SUMMATION OF IN-DEPTH INTERVIEWS

Within this segment of the atomic energy field, nuclear degreed personnel work primarily in standards and specifications and technical assistance and consulting activities. The other degreed (non-nuclear) personnel work in the following company activities:

a. Development

b. Construction

c. Production

d. Data collection, processing and analysis

e. Installations, operations and maintenance

Although there are few open positions for nuclear degreed individuals, there has been some difficulty in hiring nuclear types. With regard to the hiring of

other degreed (non-nuclear) scientists and engineers, there has been good success. There has also been success in hiring technicians.

In the future, the supply of nuclear degreed scientists and engineers is expected to be large enough to meet the demands. Furthermore, the supply of other degreed (non-nuclear) scientists and engineers will be adequate. However, although there will be a sufficient supply, there may be some difficulty in hiring the well-qualified individual. It is believed that the future supply of technicians will fall considerably short of the demand. In anticipation of this technician shortage, an attempt will be made to institute technician training programs integrating on-the-job training, short courses at a local technical and/or trade school, and training provided by their vendors.

Generally speaking, nuclear degreed individuals are hired to fill specialized technological needs but, beyond these specialized needs, scientists and engineers are hired with backgrounds in the traditional scientific and technical disciplines and given on-the-job nuclear training. Nuclear degreed personnel are hired not only to solve very specialized technical problems but secondarily, to direct the training of the company's technical staff in the technologies of nuclear science and engineering.

For future employees, a preference will be made for the degreed (non-nuclear) scientist or engineer who has had one or two courses in nuclear science and engineering. The nuclear courses that would be most applicable to the technical environment of this segment of the atomic energy field are:

a. Waste disposal
b. Reactor fuel technology
c. Radiochemistry
d. Health physics
e. Radiation safety
f. Fuel-cycle management

In addition, coursework in basic economic theory would be helpful.

In developing manpower projections, factors such as "increasing nuclear power plant generating capacities" and "dollar value of backorders" are used as reliable measures of technical manpower needs.

PRODUCTION OF SPECIAL MATERIALS FOR USE IN REACTORS

BLS Segment Definition -- Such as reactor grade graphite, boron, stainless steel, boron uranium, beryllium, dysprosium, dysprosium dispersions, hafnium, hafdispersions, polonium, silver-cadmium-indium, zirconium, zircaloy, and heavy water.

PRESENTATION OF STATISTICAL DATA

In 1968, the interviewed companies employed 58.4% of all engineers, 70.7% of all scientists, and 66.8% of all technicians working in this segment as reported to the BLS. The historical BLS data for scientists, engineers, and technicians working in the production of special materials for use in reactors segment are given below:

Historical BLS Data (1963-1968)

Year	Scientists	Engineers	Technicians	Totals
1963	68	156	344	568
1964	68	177	281	526
1965	57	121	218	396
1966	50	132	240	422
1967	43	117	243	403
1968	36	149	277	462

The data provided by the sample companies and extrapolated to the entire production of special materials for use in reactors segment for 1969, 1970 and 1973 are presented in Table 5. The overall growth of technical manpower requirements for this industry between July 1969 and December 31, 1973 is 45.1%.

Percentage increases between July 1969 and December 31, 1973 for each of the listed occupational categories are:

Occupational Categories	% Increase Between July 1969 and December 31, 1973	Numerical Increase Between July 1969 and December 31, 1973
Other Technicians	150.0%	96

Table 5

– PRODUCTION OF SPECIAL MATERIALS FOR USE IN REACTORS –

CURRENT (1969) EMPLOYMENT OF SCIENTISTS, ENGINEERS AND TECHNICIANS BY OCCUPATIONAL CATEGORIES AND ANS PROJECTIONS OF TECHNICAL MANPOWER REQUIREMENTS FOR 1970 AND 1973.

(Data include only personnel employed by privately-owned companies active in production of special materials for use in reactors who spend at least 50% of their working time in atomic energy activities.)

OCCUPATIONAL CATEGORIES	CURRENT EMPLOYMENT	1970	INCREASE/ DECREASE	1973	INCREASE/ DECREASE
PHYSICAL SCIENTISTS	90	103	+13	126	+23
LIFE SCIENTISTS	1	1	–	1	–
ENGINEERS	118	146	+28	164	+18
DRAFTSMEN	15	21	+6	21	–
ELECTRICAL & ELECTRONICS TECHNICIANS	16	19	+3	25	+6
OTHER ENGINEERING TECHNICIANS	108	109	+1	118	+9
HEALTH PHYSICS TECHNICIANS & RADIATION MONITORS	3	4	+1	4	–
PHYSICAL SCIENCE TECHNICIANS	117	133	+16	153	+20
OTHER TECHNICIANS	64	81	+17	160	+79
TOTALS	**532**	**617**	**+85**	**772**	**+155**

(Cont'd) Occupational Categories	% Increase Between July 1969 and December 31, 1973	Numerical Increase Between July 1969 and December 31, 1973
Electrical/Electronics Technicians	56.3%	9
Physical Scientists	40.0%	36
Draftsmen	40.0%	6
Engineers	39.0%	46
Health Physics Technicians & Radiation Monitors	33.3%	1
Physical Science Technicians	30.8%	36
Other Engineering Technicians	9.3%	10
Life Scientists	---	--
TOTALS	45.1%	240

Consolidating the above occupational categories into three broad categories of scientists, engineers, and technicians, shows the following percent increases between July 1969 and December 31, 1973:

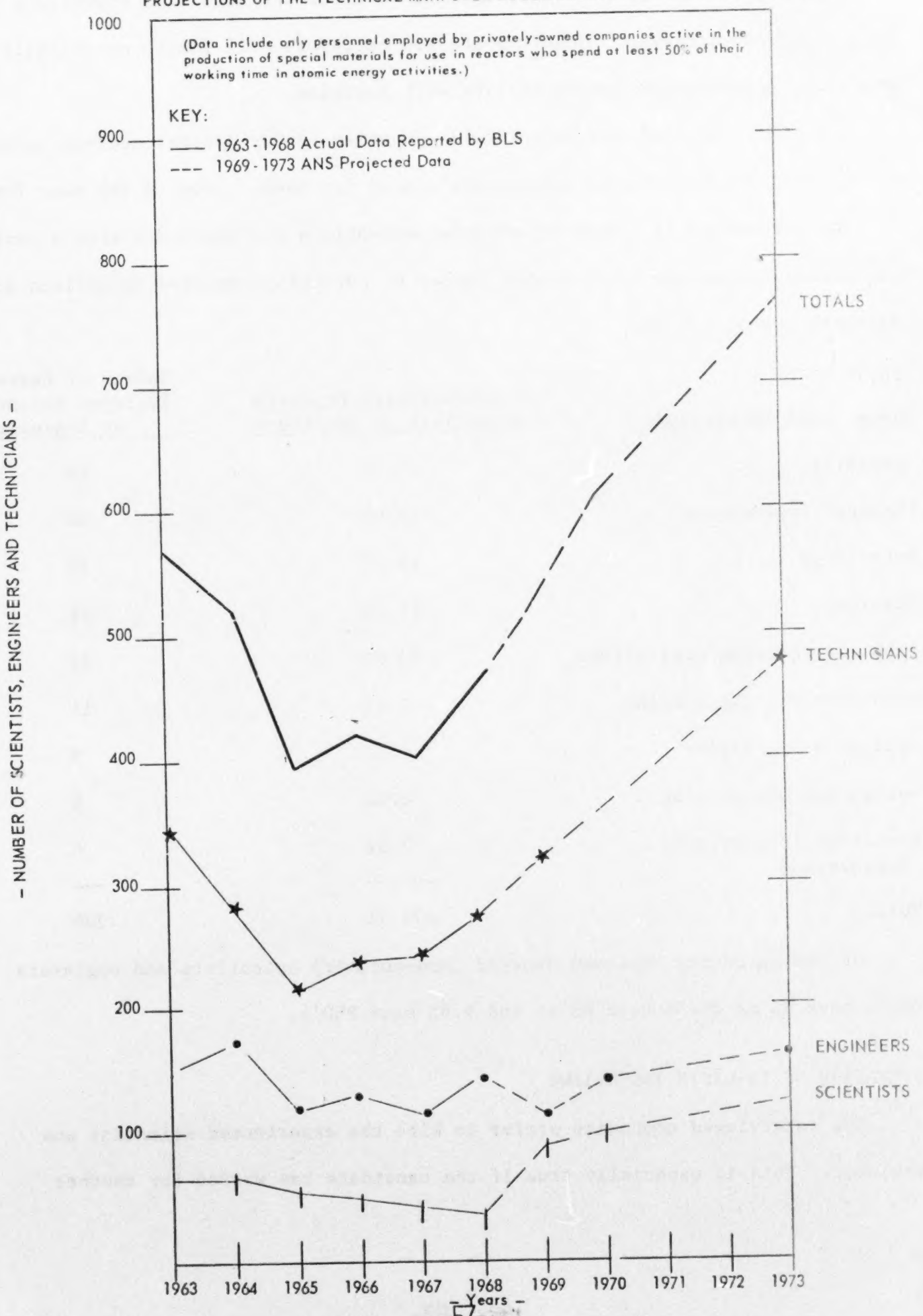
Occupational Categories	% Increase Between July 1969 and December 31, 1973	Numerical Increase Between July 1969 and December 31, 1973
Technicians (Includes draftsmen)	48.9%	158
Scientists	39.6%	36
Engineers	39.0%	46

The largest increase, both numerically and percentagewise, is in the technician category.

Chart 6 represents the actual historical BLS technical manpower data (1963-1968) for privately owned companies active in the production of special materials for use in reactors segment, and ANS projections of this segment's requirements for technical manpower through 1973. This chart shows that technicians will

Chart 6

EMPLOYMENT OF SCIENTISTS, ENGINEERS AND TECHNICIANS BY COMPANIES ACTIVE IN THE PRODUCTION OF SPECIAL MATERIALS FOR USE IN REACTORS SEGMENT OF THE PRIVATE SECTOR OF THE ATOMIC ENERGY FIELD FOR EACH YEAR EXTENDING FROM 1963 THROUGH 1968 (AS REPORTED BY THE BUREAU OF LABOR STATISTICS) AND ANS PROJECTIONS OF THE TECHNICAL MANPOWER REQUIREMENTS FOR 1969, 1970 AND 1973.



continue to be not only the largest numerical group but also will experience the largest percent increase. Requirements for engineers will remain essentially the same while requirements for scientists will increase.

Currently, none of the interviewed companies employ nuclear degreed scientists or engineers and they do not anticipate a need for these types in the near future.

The percentage of currently employed scientists and engineers with a particular educational background to the total number of currently employed scientists and engineers are as follows:

Educational Backgrounds	% of Currently Employed Scientists or Engineers	Number of Currently Employed Scientists or Engineers
Chemistry	23.5%	49
Chemical Engineering	18.9%	40
Metallurgy	18.2%	38
Physics	11.4%	24
Other Engineering Disciplines	10.6%	22
Metallurgical Engineering	7.6%	16
Geology & Geophysics	4.5%	9
Mechanical Engineering	3.0%	6
Electrical/Electronics Engineering	2.3%	5
TOTALS	100.0%	209

Of the currently employed degreed (non-nuclear) scientists and engineers, 69.7% have BS's; 20.5% have MS's; and 9.8% have PhD's.

SUMMATION OF IN-DEPTH INTERVIEWS

The interviewed companies prefer to hire the experienced scientist and engineer. This is especially true if the candidate has worked for another

company active in the atomic energy field.

During the past five years, these companies have had good to excellent success in hiring degreed qualified and experienced personnel. In 1969, however, they are experiencing some difficulty hiring these types and, as a result, they have begun to hire a greater number of recent college graduates. The companies have been successful in this endeavor and attribute their success to the fact that recent graduates prefer to associate themselves with young, growth-oriented organizations such as these companies.

With regard to the competency of young graduates, the companies believe the universities are placing too much emphasis on intradiscipline specialization. The companies prefer graduates who have a broad but basic knowledge of their profession. The companies believe this type of training allows the individual to be more flexible within the company and, therefore, more valuable.

None of the interviewed companies have employed or are planning to employ nuclear degreed scientists and engineers. They do not believe that a nuclear degreed individual would add significantly to the company's overall technical capability. One of the interviewed organizations stated: "their company is a materials oriented organization that does not need nuclear degreed individuals as they are typically oreinted to reactor technology."

The majority of their degreed employees work in the following company activities:

1. Research and development
2. Production
3. Test and evaluation
4. Standards and specifications
5. Technical assistance and consulting

PRODUCTION OF SPECIAL MATERIALS
FOR USE IN REACTORS

Although half of the companies do not believe their degreed employees would benefit from coursework in nuclear science and engineering, the remaining companies do believe their degreed technical employees would benefit. These companies would like the universities to include some nuclear courses in the traditional science and engineering curriculums. The nuclear courses they would like to see incorporated into the classical science and engineering disciplines are:

1. Reactor materials
2. Radiochemistry
3. Radiological physics
4. Health physics
5. Fuel-cycle management
6. Fuel development (uranium and plutonium)

Furthermore, they believe the universities should place more emphasis on ceramic technology.

All the interviewed companies have had good success filling their requirements for professional technicians (at least 2 years of college or technical school training). They also hire a large number of non-professional technicians for work in production activities. Professional technicians are normally assigned to research and development and test and evaluation activities. The only nuclear courses that would be of benefit to their technicians are nuclear chemistry and health physics.

"Increasing nuclear power plant generating capacities" and "sales forecasts" have historically proven to be the most reliable measures of their technical manpower requirements.

With regard to the interviewed companies evaluation of their industry's growth potential, they believe that requirements for special reactor materials

will continue to grow at the present rate through the midseventies, followed by a period of relative stability.

Fuel Element Fabrication & Recovery Activities

BLS Segment Definition -- Includes the manufacture of fuel elements and cladding materials for reactors; the recovery and chemical processing of irradiated uranium and plutonium fuels to separate fission products from irradiated fuel elements; and the scrap recovery and processing of unirradiated uranium metal, alloys, uranium, depleted dispersions, and compounds from fuel element fabrication plants.

PRESENTATION OF STATISTICAL DATA

In 1968, the interviewed companies employed 28.5% of all engineers, 14.5% of all scientists, and 22.8% of all technicians working in this segment as reported by the BLS. The historical BLS data for scientists, engineers, and technicians employed in the fuel element fabrication and recovery segment are given below:

Historical BLS Data (1963-1968)

Year	Scientists	Engineers	Technicians	Totals
1963	124	551	701	1,376
1964	137	586	766	1,489
1965	128	514	679	1,321
1966	139	496	661	1,296
1967	148	479	750	1,377
1968	207	449	858	1,514

The data provided by the sample companies and extrapolated by the ANS to the entire fuel element fabrication and recovery segment (privately owned) for 1969, 1970, and 1973 are presented in Table 6. The overall growth in technical manpower requirements for this industry between July 1969 and December 31, 1973 is 41.2%.

Table 6

– FUEL ELEMENT FABRICATION AND RECOVERY ACTIVITIES –

CURRENT (1969) EMPLOYMENT OF SCIENTISTS, ENGINEERS AND TECHNICIANS BY OCCUPATIONAL CATEGORIES AND ANS PROJECTIONS OF TECHNICAL MANPOWER REQUIREMENTS FOR 1970 AND 1973.

(Data include only personnel employed by privately-owned companies active in fuel element fabrication and recovery activities who spend at least 50% of their working time in atomic energy activities.)

OCCUPATIONAL CATEGORIES	CURRENT EMPLOYMENT	1970	INCREASE/ DECREASE	1973	INCREASE/ DECREASE
PHYSICAL SCIENTISTS	437	479	+42	650	+171
LIFE SCIENTISTS	65	77	+12	130	+53
ENGINEERS	408	475	+67	569	+94
MATHEMATICIANS	89	89	–	101	+12
DRAFTSMEN	55	69	+14	69	–
ELECTRICAL & ELECTRONICS TECHNICIANS	14	14	–	28	+14
OTHER ENGINEERING TECHNICIANS	13	13	–	23	+10
HEALTH PHYSICS TECHNICIANS & RADIATION MONITORS	125	125	–	180	+55
PHYSICAL SCIENCE TECHNICIANS	360	407	+47	517	+110
OTHER TECHNICIANS	157	157	–	166	+9
NUCLEAR MATERIALS MANAGERS	19	18	-1	27	+9
TOTALS	**1,742**	**1,923**	**+181**	**2,460**	**+537**

FUEL ELEMENT FABRICATION
& RECOVERY ACTIVITIES

The percent increases between July 1969 and December 31, 1973 for each of the listed occupational categories are:

Occupational Categories	% Increase Between July 1969 and December 31, 1973	Numerical Increase Between July 1969 and December 31, 1973
Life Scientists	100.0%	65
Electrical/Electronics Technicians	100.0%	14
Other Engineering Technicians	76.9%	10
Physical Scientists	48.7%	213
Health Physics Technicians & Radiation Monitors	44.0%	55
Physical Science Technicians	43.6%	157
Nuclear Materials Managers	42.1%	8
Engineers	39.5%	161
Draftsmen	25.5%	14
Mathematicians	13.5%	12
Other Technicians	5.7%	9
TOTALS	41.2%	718

The fact that there are large numerical requirements for physical scientists and physical science technicians points out the high priority these companies are placing on the scientific aspects of fuel technology research and development.

Consolidating the above occupational categories into three broad categories of scientists, engineers, and technicians, shows the following percent increases between July 1969 and December 31, 1973:

FUEL ELEMENT FABRICATION & RECOVERY ACTIVITIES

Occupational Categories	% Increase Between July 1969 and December 31, 1973	Numerical Increase Between July 1969 and December 31, 1973
Scientists (Includes Mathematicians	49.1%	290
Engineers	39.5%	161
Technicians (Includes Draftsmen and Nuclear Materials Managers)	35.9%	267

Chart 7 represents the actual historical BLS technical manpower data (1963-1968) for the privately owned companies active in fuel element fabrication and recovery activities, and ANS projections of this segment's requirements for technical manpower through 1973.

Requirements for scientists show the greatest increase, surpassing the total number of engineers that will be employed in this segment by 1973. Employment of technicians will drop slightly between 1968 and 1969 but numerically will increase at a rate which, by 1973, will be greater than the number of technicians employed in 1968.

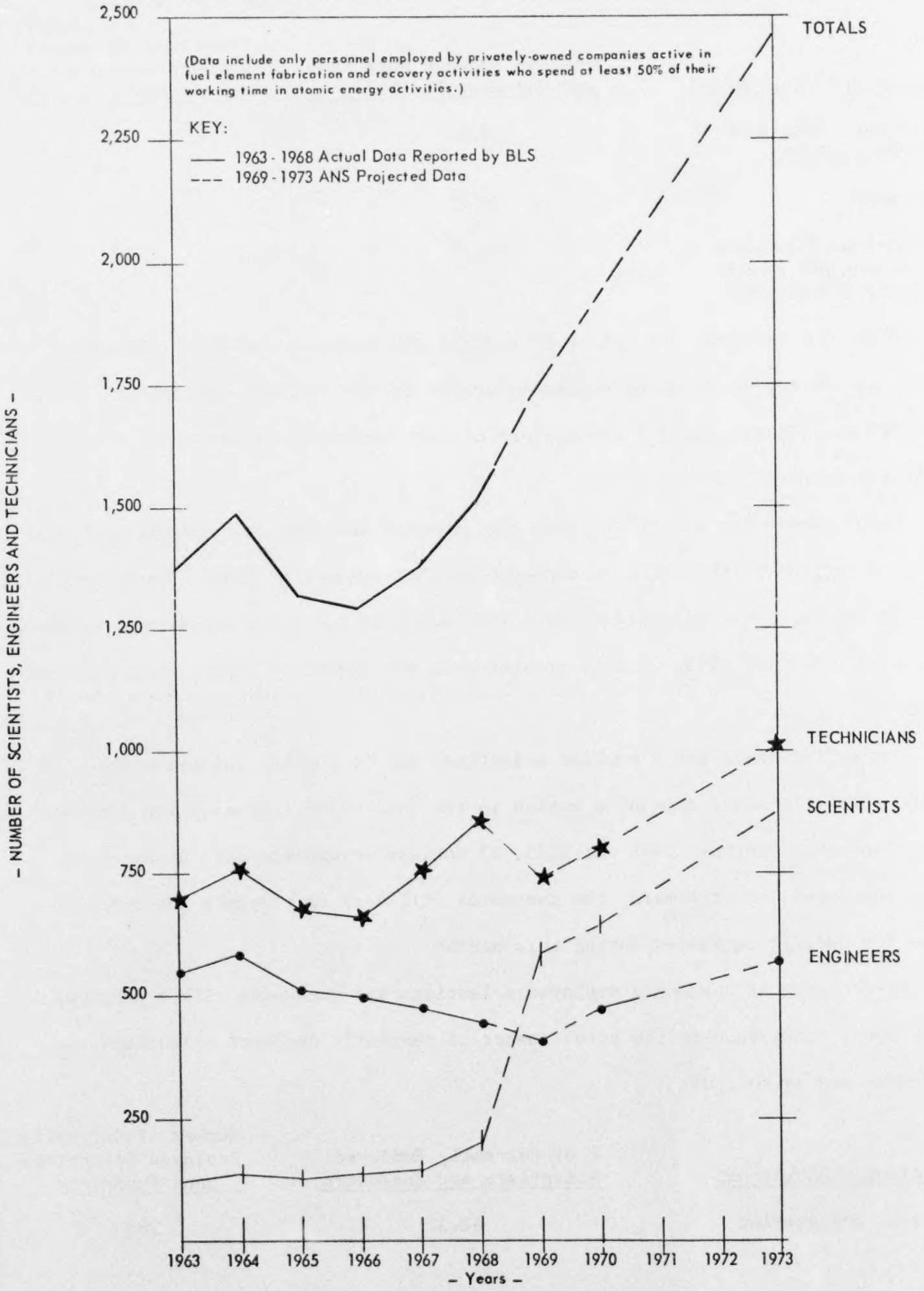
Currently, there are 6 nuclear scientists and 41 nuclear engineers employed by the privately owned companies active in the fuel element fabrication and recovery segment. Between 1969 and 1973, 47 nuclear scientists will be hired by these companies. Furthermore, the companies will more than double their requirements for nuclear engineers during this period.

Percentages of currently employed scientists and engineers with a particular educational background to the total number of currently employed scientists and engineers are as follows:

Educational Background	% of Currently Employed Scientists and Engineers	Number of Currently Employed Scientists and Engineers
Chemical Engineering	31.3%	285

Chart 7

EMPLOYMENT OF SCIENTISTS, ENGINEERS AND TECHNICIANS BY COMPANIES ACTIVE IN THE FUEL ELEMENT FABRICATION AND RECOVERY SEGMENT OF THE PRIVATE SECTOR OF THE ATOMIC ENERGY FIELD FOR EACH YEAR EXTENDING FROM 1963 THROUGH 1968 (AS REPORTED BY THE BUREAU OF LABOR STATISTICS) AND ANS PROJECTIONS OF THE TECHNICAL MANPOWER REQUIREMENTS FOR 1969, 1970 AND 1973.



FUEL ELEMENT FABRICATION
& RECOVERY ACTIVITIES

(Cont'd) Educational Backgrounds	% of Currently Employed Scientists and Engineers	Number of Currently Employed Scientists and Engineers
Chemistry	27.1%	247
Mechanical Engineering	14.6%	133
Physics	8.8%	80
Other Scientific Disciplines	4.6%	42
Nuclear Engineering	4.5%	41
Electrical/Electronics Engineering	2.5%	23
Metallurgy	2.5%	23
Other Engineering Disciplines	1.5%	14
Metallurgical Engineering	1.0%	9
Civil Engineering	0.9%	7
Nuclear Chemistry	0.7%	6
TOTALS	100.0%	910

Of the currently employed nuclear degreed scientists and engineers, 50.0% have BS's; 16.7% have MS's; and 33.3% have PhD's. Of the other degreed (non-nuclear) personnel currently employed in this segment, 89.6% have BS's; 7.7% have MS's; and 2.7% have PhD's.

The annual requirements for nuclear degreed scientists and engineers between July 1969 and December 31, 1973 to fill new positions are:

ANNUAL INCREMENTAL REQUIREMENTS FOR NUCLEAR DEGREED PERSONNEL TO FILL NEW POSITIONS

Year	Scientists	Engineers
1969 (6 mo.)	6	8
1970	12	15
1971	9	8
1972	10	9
1973	10	9

FUEL ELEMENT FABRICATION
& RECOVERY ACTIVITIES

In addition to requirements for nuclear degreed scientists and engineers to fill new positions, allowances for attrition must also be included to arrive at this segment's total technical manpower requirements for nuclear degreed personnel. (Allowances for attrition are the same as those used previously in this report: 8.4% for scientists and 7.6% for engineers.)

	Nuclear Scientists			Nuclear Engineers		
Year	Growth	Replacement	Total	Growth	Replacement	Total
1969 (6 mo.)	6	1	7	8	3	11
1970	12	2	14	15	5	20
1971	9	2	11	8	5	13
1972	10	3	13	9	6	15
1973	10	4	14	9	7	16
TOTALS	47	12	59	49	26	75
Average Annual Incremental Requirements (4½ yrs.)	10.4	2.7	13.1	10.9	5.8	16.7

Between July 1969 and December 31, 1973, a total of 134 nuclear degreed personnel will be needed by privately owned companies active in the fuel element fabrication and recovery segment of the atomic energy field. This total requirement averages out to about 30 nuclear degreed scientists and engineers each year to fill new and replacement positions within these organizations.

SUMMATION OF IN-DEPTH INTERVIEWS

The interviewed companies' degreed (non-nuclear) scientists and engineers work primarily in design and management activities. Other company activities where their degreed personnel work are research and development, test and evaluation, and standards and specifications.

Two-thirds of the interviewed companies have had considerable difficulty hiring degreed (non-nuclear) scientists and engineers. They attribute this

difficulty to an insufficient supply of scientists and engineers. Another problem these companies are experiencing is that most of the available scientists and engineers have had very little, if any, educational or working experience in nuclear technology.

The interviewed companies would like some of their degreed (non-nuclear) employees to take coursework in nuclear science and engineering. They believe that only those employees whose present job requires some knowledge of nuclear technology should take these courses. Some of the nuclear related courses these companies would like their degreed (non-nuclear) scientists and engineers to take are:

1. Reactor materials
2. Radiation shielding
3. Reactor fuel technology
4. Radiochemistry
5. Fuel-cycle management

All interviewed companies believe the supply of degreed (non-nuclear) scientists and engineers will fall short of the demand by 1970 and 1973.

Whereas these companies evaluate a potential degreed (non-nuclear) individual in terms of his experience and education, when they hire a nuclear degreed individual, they look primarily at the candidate's experience. Generally speaking, these companies do not stress, in their evaluation of a nuclear degreed individual, the extent of his education as they assume that the candidate has had advanced nuclear courses and, therefore, has the required knowledge.

The majority of their nuclear degreed personnel work in the following company activities:

1. Research
2. Contract administration

3. Design
4. Data collection, processing and analysis
5. Standards and specifications
6. Management

Each of the interviewed companies currently has a few unfilled positions for nuclear degreed scientists and engineers. Historically, the companies have always had this problem and expect it to continue in the seventies. They believe the majority of degreed scientists and engineers are hired by national laboratories, companies active in the design and engineering of nuclear facilities and companies active in reactor and reactor component manufacturing. The interviewed companies believe they would be able to attract more nuclear-degreed individuals to their organizations if graduating students were made aware of the opportunities available in the fuel fabrication and recovery industry.

The hiring patterns of the interviewed companies for nuclear degreed scientists and engineers will remain about the same as in the past (i.e., nuclear engineers and nuclear chemists). One of the companies indicated an interest in hiring health physicists. The companies believe the training and education received by nuclear engineers is very compatible with the job responsibilities they are assigned to in their organizations. One area where these companies find nuclear degreed individuals especially competent in is "criticality evaluations." However, the companies would like to see the universities place more emphasis on fuel-cycle economics.

Experience is the primary criteria for evaluating potential technician employees. Technicians, employed at these companies, work in research and production activities and, to a lesser extent, in test and evaluation, and data collection, processing and analysis activities. Nuclear materials managers work in regulatory enforcement and licensing, technical assistance, and consulting

and management activities.

The supply of qualified technicians throughout the 1970's will be so critical that most of these companies have begun training technicians themselves. Some of the nuclear courses they offer in the training of technicians are:

1. Health physics
2. Radiochemistry
3. Radiation safety
4. Fuel-handling techniques

The most reliable extrinsic factor these companies use in measuring their technical manpower needs is "increasing nuclear power plant generating capacities." The most reliable intrinsic factor is "dollar value of backorders."

The majority of the interviewed companies felt there will be a slow but gradual growth in the fuel fabrication and recovery industry until the midseventies when they expect a significant increase to occur.

Reactor and Reactor Component Design and Manufacturing

BLS Segment Definition -- The design and/or manufacture of nuclear reactors for power, test, and research purposes, and for missile and space applications, including radioisotopic power. Includes the assembly, testing and disassembly of reactors and testing materials for reactor usage.

PRESENTATION OF STATISTICAL DATA

In 1968, the interviewed companies employed 79.1% of all engineers, 62.2% of all scientists, and 73.5% of all technicians working in this segment as reported by the BLS. The historical data for scientists, engineers, and technicians employed in the reactor and reactor component design and manufacturing segment are given below:

Historical BLS Data (1963-1968)

Year	Scientists	Engineers	Technicians	Totals
1963	1,090	4,478	2,682	8,250
1964	989	4,794	3,210	8,993
1965	1,036	4,651	3,162	8,849
1966	766	3,744	2,359	6,869
1967	978	4,523	2.603	8,104
1968	1,033	5,353	3,022	9,408

The data provided by the sample companies and extrapolated by the ANS to the entire reactor and reactor component design and manufacturing segment (privately owned) for 1969, 1970, and 1973 are presented in Table 7. The overall growth in technical manpower requirements for this segment of the atomic energy field between July 1969 and December 31, 1973 is 42.3%.

Percentage increases between July 1969 and December 31, 1973 for each of the listed occupational categories are:

Table 7

– REACTOR AND REACTOR COMPONENT DESIGN AND MANUFACTURING –

CURRENT (1969) EMPLOYMENT OF SCIENTISTS, ENGINEERS AND TECHNICIANS BY OCCUPATIONAL CATEGORIES AND ANS PROJECTIONS OF TECHNICAL MANPOWER REQUIREMENTS FOR 1970 AND 1973.

(Data include only personnel employed by privately-owned companies active in reactor and reactor component design and manufacturing who spend at least 50% of their working time in atomic energy activities.)

OCCUPATIONAL CATEGORIES	CURRENT EMPLOYMENT	1970	INCREASE/ DECREASE	1973	INCREASE DECREASE
PHYSICAL SCIENTISTS	1,165	1,292	+127	1,592	+300
LIFE SCIENTISTS	90	95	+5	122	+27
ENGINEERS	4,979	5,387	+408	6,814	+1,427
MATHEMATICIANS	149	171	+22	232	+61
DRAFTSMEN	1,227	1,382	+155	1,868	+486
ELECTRICAL & ELECTRONICS TECHNICIANS	361	390	+29	557	+167
OTHER ENGINEERING TECHNICIANS	887	1,016	+129	1,364	+348
HEALTH PHYSICS TECHNICIANS & RADIATION MONITORS	116	134	+18	159	+25
LIFE SCIENCE TECHNICIANS	7	16	+9	27	+11
PHYSICAL SCIENCE TECHNICIANS	417	453	+36	669	+216
OTHER TECHNICIANS	354	390	+36	472	+82
NUCLEAR REACTOR OPERATORS	123	146	+23	175	+29
NUCLEAR MATERIALS MANAGERS	13	11	-2	16	+5
TOTALS	**9,888**	**10,883**	**+995**	**14,067**	**+3,184**

REACTOR & REACTOR COMPONENT
DESIGN & MANUFACTURING

Occupational Categories	% Increase Between July 1969 and December 31, 1973	Numerical Increase Between July 1969 and December 31, 1973
Life Science Technicians	285.7%	20
Physical Science Technicians	60.4%	252
Mathematicians	55.7%	83
Electrical/Electronics Technicians	54.3%	196
Other Engineering Technicians	53.8%	477
Draftsmen	52.2%	641
Nuclear Reactor Operators	42.3%	52
Health Physics Technicians & Radiation Monitors	37.1%	43
Engineers	36.9%	1,835
Physical Scientists	36.7%	427
Life Scientists	35.6%	32
Other Technicians	33.3%	118
Nuclear Materials Managers	23.1%	3
TOTALS	42.3%	4,179

Although the engineer category shows the largest numerical increase, seven of the first eight categories, ranked by percent increase between 1969 and 1973, are occupied by technician-level personnel. This emphasis on technician-level personnel reflects the transition of these companies from primarily research and development operations to product design and manufacturing organizations.

Consolidating the above occupational categories into three broad categories of scientists, engineers, and technicians, shows the following percent increases between July 1969 and December 31, 1973:

REACTOR & REACTOR COMPONENT
DESIGN & MANUFACTURING

Occupational Categories	% Increase Between July 1969 and December 31, 1973	Numerical Increase Between July 1969 and December 31, 1973
Technicians (Includes Draftsmen, Nuclear Reactor Operators, and Nuclear Materials Managers)	51.4%	1,802
Scientists (Includes Mathematicians)	38.6%	542
Engineers	36.9%	1,835

Chart 8 represents the actual historical BLS technical manpower data (1963-1968) for the non-government-owned companies active in reactor and reactor component design and manufacturing activities, and ANS projections of this segment's requirements for technical personnel through 1973.

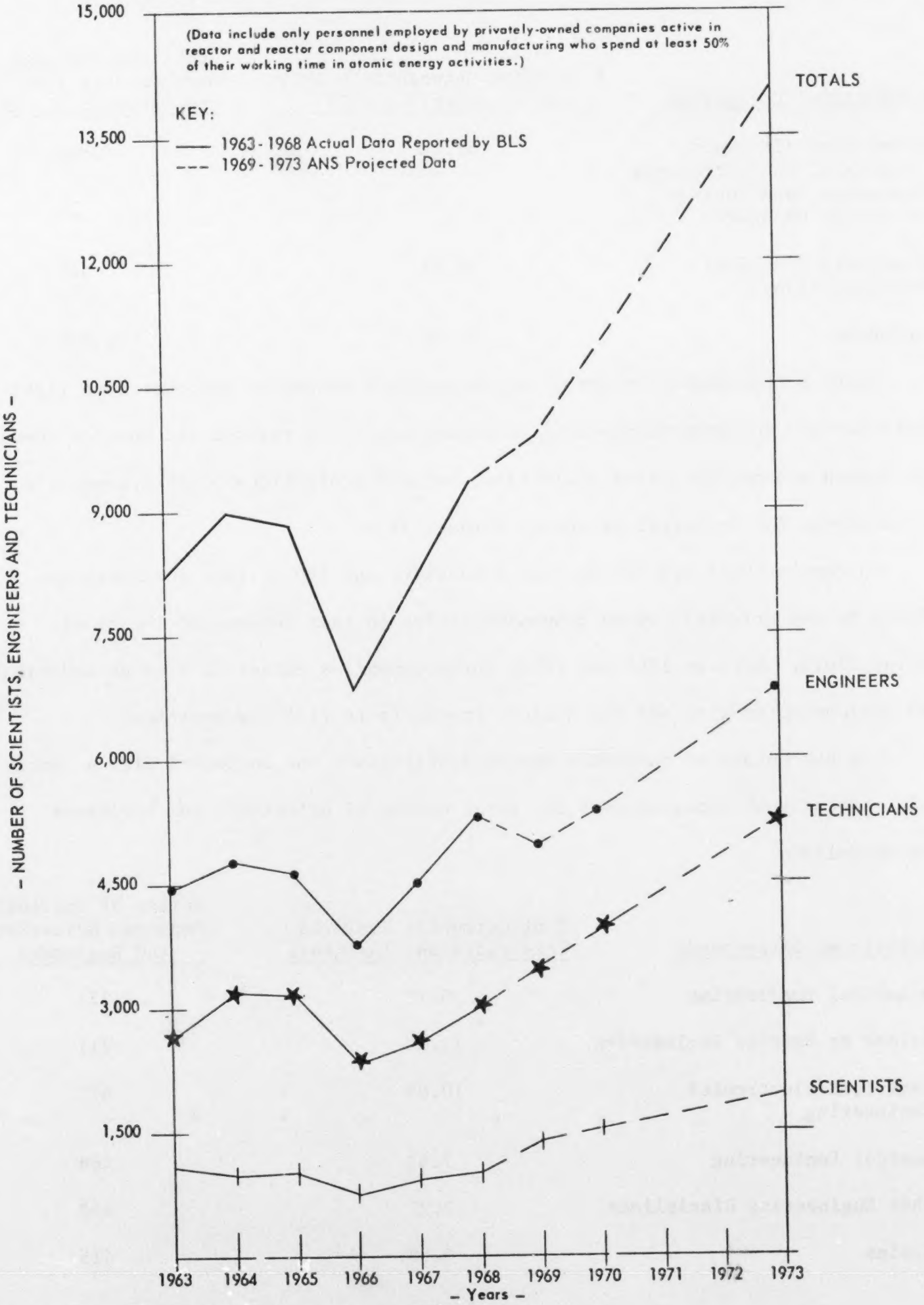
Currently there are 446 nuclear scientists and 530 nuclear engineers employed by the privately owned companies active in this segment of the atomic energy field. Between 1969 and 1973, these companies expect to hire an additional 193 nuclear scientists and 228 nuclear engineers to fill new positions.

The percentage of currently employed scientists and engineers with a particular educational background to the total number of scientists and engineers are as follows:

Educational Backgrounds	% of Currently Employed Scientists and Engineers	Number of Currently Employed Scientists and Engineers
Mechanical Engineering	38.1%	2,371
Nuclear or Reactor Engineering	11.3%	711
Electrical/Electronics Engineering	10.8%	673
Chemical Engineering	7.5%	468
Other Engineering Disciplines	7.2%	447
Physics	6.6%	415

Chart 8

EMPLOYMENT OF SCIENTISTS, ENGINEERS AND TECHNICIANS BY COMPANIES ACTIVE IN THE REACTOR AND REACTOR COMPONENT DESIGN AND MANUFACTURING SEGMENT OF THE PRIVATE SECTOR OF THE ATOMIC ENERGY FIELD FOR EACH YEAR EXTENDING FROM 1963 THROUGH 1968 (AS REPORTED BY THE BUREAU OF LABOR STATISTICS) AND ANS PROJECTIONS OF THE TECHNICAL MANPOWER REQUIREMENTS FOR 1969, 1970 AND 1973.



REACTOR & REACTOR COMPONENT DESIGN & MANUFACTURING

(Cont'd) Educational Backgrounds	% of Currently Employed Scientists and Engineers	Number of Currently Employed Scientists and Engineers
Metallurgical Engineering	5.2%	321
Chemistry	3.9%	242
Nuclear Physics	2.5%	159
Other Science Disciplines	1.7%	105
Civil Engineering	1.6%	100
Metallurgy	1.6%	100
Health Physics	0.8%	48
Other Nuclear Science and Engineering Disciplines	0.5%	29
Nuclear Chemistry	0.4%	26
Geology and Geophysics	0.2%	16
High Energy Physics	0.1%	3
TOTALS	100.0%	6,234

Of the currently employed nuclear degreed scientists and engineers, 25.2% have BS's; 56.2% have MS's: and 18.6% have PhD's. Of the other degreed (non-nuclear) personnel currently employed in this segment of the atomic energy field, 66.3% have BS's; 26.9% have MS's; and 6.8% have PhD's.

The annual requirements for nuclear degreed scientists and engineers between July 1969 and December 31, 1973 to fill new positions are:

ANNUAL INCREMENTAL REQUIREMENTS FOR NUCLEAR DEGREED PERSONNEL TO FILL NEW POSITIONS

Year	Scientists	Engineers
1969 (6 mo.)	23	23
1970	46	46
1971	41	53
1972	41	53
1973	42	53

REACTOR & REACTOR COMPONENT
DESIGN & MANUFACTURING

In addition to this segment's need for nuclear degreed scientists and engineers to fill new positions, allowances for attrition must also be included to arrive at the total technical manpower requirements for nuclear degreed personnel. (Allowances for attrition are the same as those used previously in this report: 8.4% for scientists and 7.6% for engineers.)

	Nuclear Scientists			Nuclear Engineers		
Year	Growth	Replacement	Total	Growth	Replacement	Total
1969 (6 mo.)	23	37	60	23	40	63
1970	46	43	89	46	46	92
1971	41	46	87	53	50	103
1972	41	50	91	53	54	107
1973	42	54	96	53	58	111
TOTALS	193	230	423	228	248	476
Average Annual Incremental Requirements (4½ yrs.)	42.9	51.1	94.0	50.7	55.1	105.8

Between July 1969 and December 31, 1973, a total of 899 nuclear degreed personnel will be needed by all privately owned companies active in the reactor and reactor component design and manufacturing segment. This requirement averages out to about 200 nuclear degreed scientists and engineers each year to fill new and replacement positions within these organizations.

SUMMATION OF IN-DEPTH INTERVIEWS

The primary employment qualification these companies consider when hiring degreed (non-nuclear) scientists and engineers is experience. They also evaluate the candidate's "track record" and whether or not the individual has a keen interest in the nuclear field. However, when these companies hire recent college graduates they put considerably more emphasis on the level of degree earned plus a subjective evaluation of the candidate's future potential.

The company activities where the degreed (non-nuclear) employees work are:

1. Design (17%)
2. Development (12%)
3. Test and evaluation (10%)
4. Production (13%)
5. Research (5%)
6. Other activities (42%)

Half of the interviewed companies have had good success in hiring degreed (non-nuclear) scientists and engineers during the past five years. These companies attribute their success to: 1) the growth and newness of the nuclear field: 2) their company's geographical location; 3) the individual's growth potential at their company: and, 4) the diversity of their company's operations. The remaining 50% of the interviewed companies have had some difficulty in filling their needs for degreed (non-nuclear) personnel. Two of the major reasons given for this difficulty are: 1) the over-whelming demand, on a national basis, for degreed personnel -- especially engineers; and 2) the extremely high salary levels being demanded by potential employees.

As to whether or not these companies felt they would be able to fill their requirements for degreed (non-nuclear) scientists and engineers in the early 1970's, the majority of the companies indicated that they were cautiously

optimistic. They noted the apparent decrease in engineering enrollments and expressed some concern over the effect of the military draft on students who would normally go on to graduate school. Generally speaking, these companies believe they will be able to hire enough scientists and engineers to meet their 1970 and 1973 requirements, but they might have to pay more.

All interviewed companies felt that they would like their degreed (non-nuclear) scientists and engineers to have some coursework in nuclear science or engineering. Some of the nuclear courses they would like the universities to make available to science and engineering (non-nuclear) students are:

1. Reactor fuel technology
2. Reactor materials
3. Reactor design
4. Nuclear metallurgy
5. A survey course in the fundamentals of nuclear engineering

When hiring a scientist or engineer with a degree in nuclear science or engineering, these companies use the same employment criteria as when they hire scientists and engineers in general. However, two of the interviewed companies pointed out that within their company there seems to be a trend for the supervisory managers to specify master's degreed nuclear engineers in their job descriptions.

About 43% of the nuclear degreed personnel work in research activities, 20% in development, 9% in test and evaluation, 9% in design, and 10% in regulatory enforcement and licensing activities. The remaining portion of nuclear degreed personnel work in management and data collection, processing and analysis activities.

During the past five years, all interviewed companies have had relatively good success in filling their needs for nuclear degreed personnel. The most prevalent reason given for their success in hiring nuclear degreed scientists and engineers was that these organizations are at the forefront of the nuclear field and, as a result, they attract people who want to be where the "action" is. Twenty-eight percent of the interviewed companies have filled their need for nuclear degreed individuals. These two companies are primarily research oriented organizations and, as a result, they believe their success is due to the company's work environment (creativity and quality of the staff and highly competitive salaries). The remaining companies currently have some unfilled positions for nuclear degreed personnel. Some of the reasons given for those open positions are: 1) the somewhat limited supply of nuclear scientists and engineers at certain levels of education; 2) the company is undergoing a very rapid growth; and, 3) open positions (nuclear or non-nuclear) are a natural consequence of large organizations.

During the past five years, seventy percent of the interviewed companies have increased their requirements for nuclear degreed scientists and engineers. This increase is due to the companies' increased activity in the nuclear field and the resulting technical sophistication this technology requires. Although requirements for nuclear degreed scientists and engineers have increased, the companies are placing more of their nuclear degreed personnel in operational activities such as reactor safety, licensing, fuel-cycle management, etc., rather than in research activities. Also, the companies have begun to de-emphasize the employment of PhD's while placing emphasis on the MS level.

When these companies were asked why they don't hire more nuclear degreed scientists and engineers their responses included: 1) there is a great deal

of work which doesn't require the technical sophistication of a nuclear engineer; 2) the nuclear degreed individual, being so specialized, limits his overall usefulness to the company (the technical specialization of the nuclear engineer "pigeonholes" him within the company); 3) experience has shown that a degreed (non-nuclear) individual with some nuclear training (in-house training or through short courses at a university) can do as good a job as a nuclear degreed individual; and, 4) only a small percentage of the work, although extremely important, requires a nuclear degreed individual (i.e., core design, safety analysis, shielding, etc.). It is interesting to note, however, that nuclear degreed individuals are usually placed in management positions. They are given these managerial responsibilities not only to direct the work activities relating to their technical specialization but also to provide, directly and indirectly, nuclear training to their other degreed (non-nuclear) personnel.

In response to the question regarding their evaluation of the nuclear degreed individual's educational training, the interviewed companies provided the following comments: 1) as is the case with other engineering and scientific disciplines, these companies have special technological and operational needs that are not being offered by the educational institutions; 2) the educational background of the nuclear degreed individual is oriented to theoretical considerations; 3) like most recent graduates, the nuclear degreed individual has little concept of what the industrial environment is really like. In this regard, many recent MS's and, in particular, PhD's believe their job will be the same as a post-graduate research project. When the young graduate fails to understand the real nature of the industrial setting, disappointment and dissatisfaction are the usual consequences.

One of the more interesting points brought out in the interviews was that these companies will hire nuclear degreed scientists and engineers in the 1970's

to assume job responsibilities associated with putting nuclear power plants into operation. The nuclear courses these companies would like to see emphasized in the training of nuclear engineers are: reactor fuel technology, reactor materials, reactor design and analysis, and fuel-cycle management. They would also like the universities to emphasize fuel-cyle analysis, control theory, and systems engineering. They foresee a need for more people with radiochemistry backgrounds but believe this training should come under the auspices of the chemistry departments.

What follows are a few more detailed evaluations of nuclear science and engineering graduates as they relate to the technical requirements of companies active in the reactor and reactor component design and manufacturing segment.

"The nuclear engineer noticeably lacks a practical understanding of the problems facing the nuclear field today." Specialization at the BS level results in an engineer with "tunnel vision." For the thermohydraulic and mechanical aspects of reactor engineering, a solid background in one of the traditional engineering disciplines topped off with a year or so of formal work in nuclear reactor theory or nuclear metallurgy seems best for their needs. Although the companies generally classify the BS nuclear engineer as too specialized -- too soon, they believe that as the nuclear industry grows more job opportunities will begin to exist for people with a BS level nuclear engineering education. These opportunities might be expected to occur most often in the operational sector of the nuclear business such as AEC surveillance, utility shift supervision. utility business management (ideally a BS nuclear engineer with a MBA) and other related operational activities.

One of the interviewed companies was extremely vocal on the question of the relative merits of the BS nuclear engineer. This company favors the insertion of appropriate elements of nuclear technology into the classical

engineering disciplines at the BS level but does not favor a special BS nuclear engineering degree. They also feel that if the universities continue to stress BS nuclear engineers, engineers from other disciplines might avoid the nuclear field on the basis that their educational background would not be appropriate. This company would like to see the classical engineering disciplines adjusted for nuclear technology so that each BS engineering student would enter the field with confidence and sufficient technical background to make a meaningful contribution. Furthermore, this company believes that an over-emphasis on nuclear engineering at the BS level would leave these individuals deficient in the elements of basic engineering which are vital to their future success. For nuclear engineering students at the MS and PhD levels, there should be a greater emphasis placed on such areas as heat transfer, reactor materials, reactor fuel technology, etc.

Some of the companies believe there are some very special needs arising from the nuclear field that may require some special education and training. These needs concern the matter of operating nuclear power plants. They see the emergence of what might be termed a nuclear technologist or nuclear operations engineer. Individuals are needed to supervise the technical elements of the operation of nuclear power plants. Areas here are: reactor control, systems dynamics, fuel management, health physics, environmental effects--contamination and systems safety.

The primary employment qualification for technician-level personnel is the candidate's prior work experience and the extent of his training. Technicians employed in this industry work primarily in test and evaluation activities (34%). About 11% of their technicians work in developmental activities; 11% in installations, operations and maintenance activities; 9% in data collection, processing and analysis; 9% in technical assistance and consulting; and, the remainder in research, design, construction, and production activities.

REACTOR & REACTOR COMPONENT
DESIGN & MANUFACTURING

The interviewed companies have had good success in hiring technicians during the past five years. They attribute this success to their geographic location where there is a high concentration of qualified technicians. Only one of the interviewed companies expected a shortage of technicians in 1973 and, as a result, they are establishing an in-house technician training program.

The nuclear related courses these companies would like their technicians to have are: reactor instrumentation, radiological physics, radioisotope techniques, radiation safety, fuel handling, and health physics. If technicians have not had these courses, the companies provide the necessary training through "in-house" programs, in association with a college or technical school, or in association with their vendors.

The employment qualifications these companies consider when hiring a nuclear reactor operator and/or nuclear materials manager is a combination of experience and training. The majority of their nuclear reactor operators work in installation, operations, and maintenance activities. The remaining nuclear reactor operators are employed in production, development, test and evaluation, construction, and regulatory enforcement and licensing activities. Nuclear materials managers work almost exclusively in regulatory enforcement and licensing although some also work in planning and management activities.

None of the interviewed companies have had any difficulty in hiring nuclear reactor operators and nuclear materials managers. Furthermore, they do not anticipate any difficulty in filling their needs in 1970 or 1973.

The nuclear related courses which are most applicable to these companies' nuclear reactor operators are: reactor instrumentation; reactor engineering; radiation safety; general instrumentation; and, fuel handling. Nuclear courses that would benefit their nuclear materials managers are: waste disposal; reactor fuel technology; reactor materials; nuclear metallurgy; nuclear chemistry; radio-

isotope techniques; radiation safety; and, fuel handling.

The two most reliable intrinsic factors these companies use when forecasting their technical manpower requirements are "sales forecasts of atomic energy products, materials, and/or services," and "dollar value of backorders of atomic energy products, materials and/or services." The three most reliable extrinsic factors used by these companies in developing technical manpower requirements are "increasing nuclear power plants generating capacities," "general economic outlook," and "projections of government funds."

Forty percent of the interviewed companies indicated that a 10% decrease in government funds to their companies would not affect their technical manpower estimates for 1970 or 1973. The remaining companies stated that a 10% decrease in government funds would result in about a 2-5% reduction in their manpower estimates. Generally speaking, substantial decreases in employment would occur only if government funds were to decrease by 20-30%. If government funds were to decrease by this amount, their manpower reductions would occur "across-the-board" but perhaps less so with nuclear degreed personnel.

DESIGN AND ENGINEERING OF NUCLEAR FACILITIES

BLS Segment Definition -- Design and engineering of all nuclear facilities other than reactors.

PRESENTATION OF STATISTICAL DATA

In 1968, the interviewed companies employed 61.0% of all engineers, 32.9% of all scientists, and 50.6% of all technicians working in this segment as reported by BLS. The historical data for scientists, engineers, and technicians employed in the design and engineering of nuclear facilities segment (non-government-owned) are given below:

	Historical BLS Data (1963-1968)			
Year	Scientists	Engineers	Technicians	Totals
1963	80	1,027	634	1,741
1964	57	1,045	924	2,038
1965	60	1,139	848	2,047
1966	87	1,521	864	2,472
1967	111	2,222	1,329	3,662
1968	85	2,479	1,901	4,465

Data provided by the sample companies and extrapolated by the ANS to the entire design and engineering of nuclear facilities segment (privately owned) for 1969, 1970 and 1973 are presented in Table 8. The overall growth in technical manpower requirements for this segment of the atomic energy field between July 1969 and December 31, 1973 is 48.2%.

The percent increases between July 1969 and December 31, 1973 for each of the listed occupational categories are:

Occupational Categories	% Increase Between July 1969 and December 31, 1973	Numerical Increase Between July 1969 and December 31, 1973
Health Physics Technicians and Radiation Monitors	167.5%	134
Nuclear Materials Managers	162.5%	39

Table 8

– DESIGN AND ENGINEERING OF NUCLEAR FACILITIES –

CURRENT (1969) EMPLOYMENT OF SCIENTISTS, ENGINEERS AND TECHNICIANS BY OCCUPATIONAL CATEGORIES AND ANS PROJECTIONS OF TECHNICAL MANPOWER REQUIREMENTS FOR 1970 AND 1973.

(Data include only personnel employed by privately-owned companies active in design and engineering of nuclear facilities who spend at least 50% of their working time in atomic energy activities.)

OCCUPATIONAL CATEGORIES	CURRENT EMPLOYMENT	1970	INCREASE/ DECREASE	1973	INCREASE/ DECREASE
PHYSICAL SCIENTISTS	228	238	+10	274	+36
LIFE SCIENTISTS	24	25	+1	33	+8
ENGINEERS	1,685	2,018	+333	2,374	+356
MATHEMATICIANS	96	107	+11	123	+16
DRAFTSMEN	1,458	1,762	+304	2,513	+751
ELECTRICAL & ELECTRONICS TECHNICIANS	57	42	-15	47	+5
OTHER ENGINEERING TECHNICIANS	322	194	-128	287	+93
HEALTH PHYSICS TECHNICIANS & RADIATION MONITORS	80	149	+69	214	+65
OTHER TECHNICIANS	86	80	-6	88	+8
NUCLEAR REACTOR OPERATORS	4	6	+2	8	+2
NUCLEAR MATERIALS MANAGERS	24	42	+18	63	+21
TOTALS	**4,064**	**4,663**	**+599**	**6,024**	**+1,361**

(cont'd) Occupational Categories	% Increase Between July 1969 and December 31, 1973	Numerical Increase Between July 1969 and December 31, 1973
Nuclear Reactor Operators	100.0%	4
Draftsmen	72.4%	1,055
Engineers	40.9%	689
Life Scientists	37.5%	9
Mathematicians	28.1%	27
Physical Scientists	20.2%	46
Other Technicians	2.3%	2
Other Engineering Technicians	-10.9%	-35
Electrical/Electronics Technicians	-17.5%	-10
TOTALS	48.2%	1,960

Together, the occupational categories of engineers and draftsmen represent nearly 89.0% of the estimated technical manpower this segment will hire to fill new positions between 1969 and 1973. The large increase, percentagewise, in the health physics technicians category reflects the requirements of only fifteen percent of the seven interviewed companies.

Consolidating the above occupational categories into three broad categories of scientists, engineers, and technicians, shows the following percent increases between 1969 and 1973:

Occupational Categories	% Increase Between July 1969 and December 31, 1973	Numerical Increase Between July 1969 and December 31, 1973
Technicians (Includes Draftsmen, Nuclear Reactor Operators and Nuclear Materials Managers)	58.5%	1,189
Engineers	40.9%	689
Scientists (Includes Mathematicians)	23.6%	82

DESIGN AND ENGINEERING OF NUCLEAR FACILITIES

Approximately 88.7% of this segment's requirement for technicians will be for draftsmen. . This is probably due to the fact that these organizations have had enough experience in nuclear facilities design and engineering and, therefore, for subsequent design standardization, draftsmen will be taking over a greater portion of the work.

Chart 9 represents the actual historical BLS technical manpower data (1963-1968) for the entire non-government-owned companies active in design and engineering of nuclear facilities segment and ANS projections of this segment's requirements for technical personnel through 1973. The large drop in the engineer category between 1968 and 1969 may be due to the problem of identifying, at any point in time, the number of technical people who spend at least 50% of their working time in atomic energy activities in that these organizations assign their personnel to a number of projects throughout the year of which nuclear projects are just a few. The result is that the companies in this segment of the atomic energy field probably have difficulty identifying members of their staff who spend at least 50% of their time on nuclear related projects.

Currently, there are 30 nuclear scientists and 118 nuclear or reactor engineers employed by the privately owned companies active in this segment of the atomic energy field. Between 1969 and 1970, these companies expect to hire an additional 36 nuclear scientists and 98 nuclear or reactor engineers to fill new positions.

The percentage of currently employed scientists and engineers with a particular educational background to the total number of scientists and engineers are as follows:

Educational Backgrounds	% of Currently Employed Scientists and Engineers	Number of Currently Employed Scientists and Engineers
Mechanical Engineering	36.4%	705

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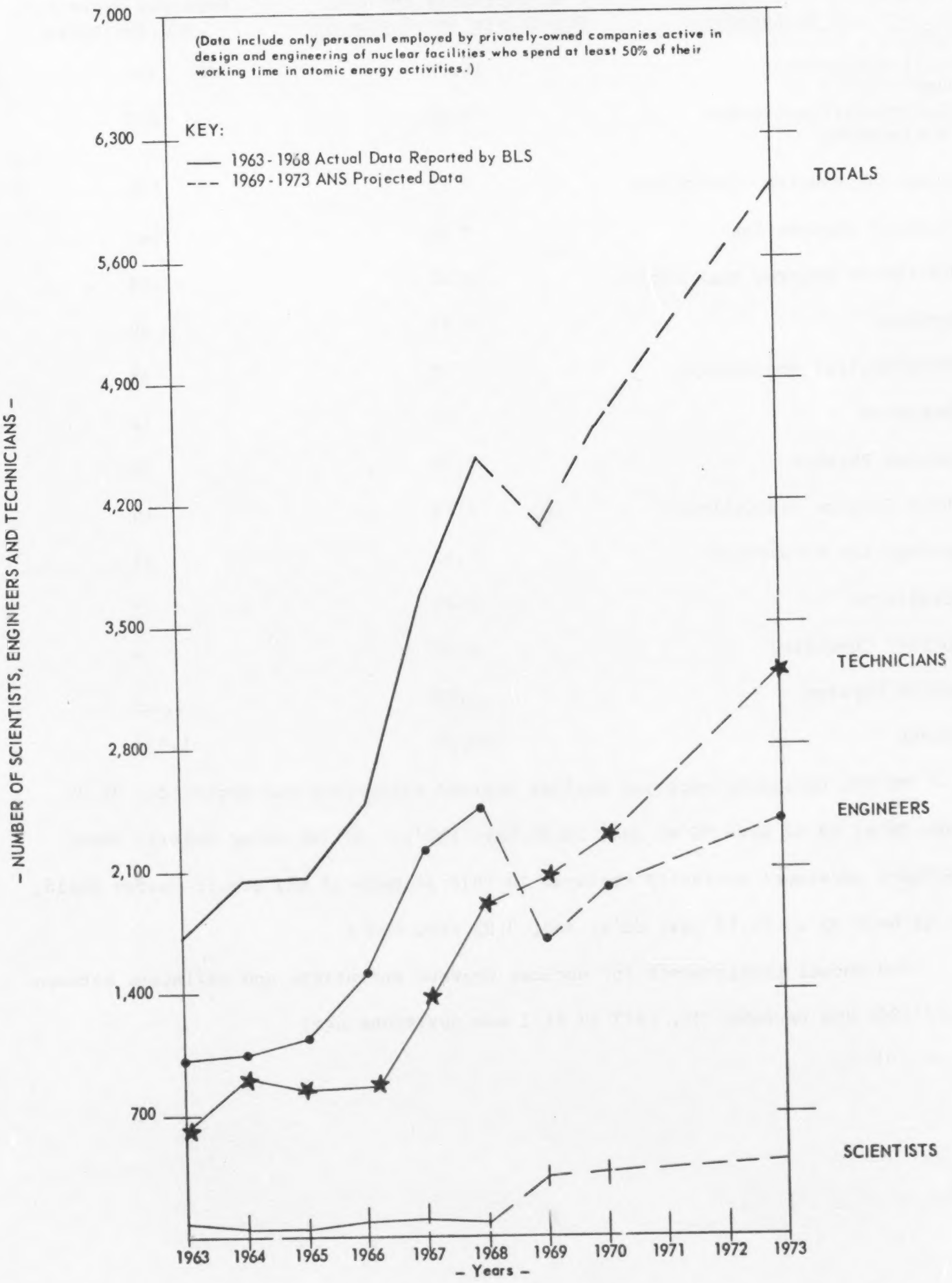
Chart 9

EMPLOYMENT OF SCIENTISTS, ENGINEERS AND TECHNICIANS BY COMPANIES ACTIVE IN THE DESIGN AND ENGINEERING OF NUCLEAR FACILITIES SEGMENT OF THE PRIVATE SECTOR OF THE ATOMIC ENERGY FIELD FOR EACH YEAR EXTENDING FROM 1963 THROUGH 1968 (AS REPORTED BY THE BUREAU OF LABOR STATISTICS) AND ANS PROJECTIONS OF THE TECHNICAL MANPOWER REQUIREMENTS FOR 1969, 1970 AND 1973.



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(Cont'd) Educational Backgrounds	% of Currently Employed Scientists and Engineers	Number of Currently Employed Scientists and Engineers
Civil Engineering	16.7%	324
Electrical/Electronics Engineering	15.0%	292
Other Engineering Disciplines	9.1%	175
Chemical Engineering	7.3%	141
Nuclear or Reactor Engineering	6.4%	128
Physics	3.4%	66
Metallurgical Engineering	1.5%	29
Chemistry	1.3%	25
Nuclear Physics	0.7%	14
Other Science Disciplines	0.7%	14
Geology and Geophysics	0.5%	11
Metallurgy	0.4%	7
Nuclear Chemistry	0.3%	4
Health Physics	0.3%	2
TOTALS	100.0%	1,937

Of the currently employed nuclear degreed scientists and engineers, 37.3% have BS's; 49.4% have MS's; and, 13.2% have PhD's. Of the other degreed (non-nuclear) personnel currently employed in this segment of the atomic energy field, 75.1% have BS's; 21.1% have MS's; and, 3.8% have PhD's.

The annual requirements for nuclear degreed scientists and engineers between July 1969 and December 31, 1973 to fill new positions are:

ANNUAL INCREMENTAL REQUIREMENTS FOR NUCLEAR DEGREED PERSONNEL TO FILL NEW POSITIONS

Year	Scientists	Engineers
1969 (6 mo.)	6	15
1970	13	29
1971	5	18
1972	6	18
1973	6	18

In addition to this segment's need for nuclear degreed scientists and engineers to fill new positions, allowances for attrition must also be included to arrive at the segment's total technical manpower requirements of nuclear degreed personnel. (Allowances for attrition are the same as those used previously in this report: 8.4% for scientists and 7.6% for engineers.)

	Nuclear Scientists			Nuclear Engineers		
Year	Growth	Replacement	Total	Growth	Replacement	Total
1969 (6 mo.)	6	3	9	15	9	24
1970	13	4	17	29	12	41
1971	5	4	9	18	13	31
1972	6	5	11	18	14	32
1973	6	6	12	18	16	34
TOTALS	36	22	58	98	64	162
Average Annual Incremental Requirements (4½ yrs.)	8.0	4.9	12.9	21.8	14.2	36.0

Between July 1969 and December 31, 1973, 220 nuclear degreed personnel will be needed by all privately owned companies active in the design and engineering of nuclear facilities segment. This requirement averages out to about 49 nuclear degreed scientists and engineers each year to fill new and replacement positions within these organizations.

DESIGN AND ENGINEERING OF NUCLEAR FACILITIES

SUMMATION OF IN-DEPTH INTERVIEWS

When evaluating potential employees, these companies do not consider the candidate's earned level of degree as being more important than his demonstrated ability. Level of degree is considered only as a measure of the candidate's extent of education. In the case of the recent graduate, level of degree plays a more important role but these companies still place considerable emphasis on the candidate's potential usefulness to the company.

Specifically, these organizations look for the experienced man--experienced in the technology in which the company needs additional support. What the potential employee's qualifications should be are determined by the "job description" prepared by the requisitioning supervisor who stipulates the required training, experience, and education.

Degreed (non-nuclear) personnel work primarily in design activities although some also work in development, standards and specifications, and management activities.

The majority of the interviewed companies have had little, if any, difficulty in filling their need for degreed (non-nuclear) personnel during the past five years. They attribute their success not only to the traditional considerations of company benefits, nature of the work, etc., but also to the fact that their company is located in an ideal geographical area of the country.

The remaining companies have experienced considerable difficulty attracting degreed individuals to adequately fill their requirements. Specifically, these organizations have not been able to hire enough project engineers in mechanical, electrical, or civil engineering.

With regard to the future supply of degreed (non-nuclear) individuals, most of the interviewed companies anticipate no trouble in meeting their technical manpower requirements while a few of the remaining companies do foresee a

continuing recruitment problem. They see this difficulty arising from the increasing number of technological industries and their subsequent technical manpower demands coupled with apparent reductions in engineering enrollments.

The overwhelming opinion of the interviewed companies was that nuclear-related survey courses should be incorporated in the undergraduate classical engineering curriculums. Generally speaking, these organizations prefer the engineer who has been trained in a classical engineering discipline and who has had one or two courses in nuclear technology. This type of individual is more valuable because his training is broad enough to allow him flexibility in assuming various company assignments.

Some of the nuclear courses these companies would like their degreed (non-nuclear) employees to take are waste disposal, radiation shielding, reactor engineering, reactor analysis, fuel-cycle management, and radiation shielding. They would also like the universities to establish more courses in licensing and computer science and data analysis. Courses in business economics would also be beneficial.

The companies use the same approach when hiring a nuclear degreed scientist or engineer as they do when they hire a scientist or engineer in general. The reason why these organizations have hired and are continuing to hire nuclear degreed scientists and engineers is because the companies need expertise in an area of technology which is not currently available from the present staff.

In addition to hiring a nuclear degreed individual to ensure the companies' nuclear capabilities, the nuclear degreed individual is also expected to provide nuclear training for the rest of the technical staff. It must be realized that the nuclear degreed person is hired to fill a technological void existing within the company -- when specialized knowledge is needed, they hire a specialist! However, the work performed by the nuclear degreed individual amounts to less

than 5% of the total project's design and engineering requirements and, as the rest of the staff gains competency in nuclear technology, there is little need to hire more nuclear degreed individuals. The specific tasks the nuclear engineer is responsible for are; safety analysis, reactor shielding, licensing, fuel-cycle management, and radiation safety considerations. The reason why these companies do not hire more nuclear degreed scientists and engineers is that they (the companies) have been successful in applying the traditional engineering disciplines to nuclear applications.

Generally speaking, the companies believe the nuclear degreed individual to be very competent in his field of endeavor. However, it is also this specialization that the companies criticize. Because the nuclear degreed individual is so specialized, his flexibility within the organization is somewhat limited unless he has managerial potential. For these companies, the really useful man is the one who has a broad background in applied engineering. Such an individual is rarely "pigeon-holed" within the organization.

All interviewed companies have increased their requirements for nuclear degreed personnel during the past five years and foresee a continuing increase in their requirements through 1973. This increase, although small in comparison to their overall manpower requirements, is due to their awareness of the expertise a nuclear degreed scientist or engineer brings to the job.

Technicians are hired without too much concern with their education and training, as these organizations are willing to provide "in-house" training programs. Obviously, the companies would like to hire qualified professional technicians but, because of the acute shortage of these individuals, the companies are beginning to hire a greater number of untrained individuals and training them themselves. Because of the extreme shortage of professional technicians, technicians are more mobile because companies in all technological industries are willing to pay a premium for their services. It is also interesting to note

how highly these organizations value Navy trained technicians.

Technicians employed by these companies work almost exclusively in design activities. For their professional technicians, the companies would like them to have some coursework in waste disposal, radiation sheilding, reactor instrumentation, and radiation shielding.

The primary extrinsic factors these companies consider when forecasting their technical manpower requirements are "nuclear power plant generating capacities," "possible new applications of atomic energy," and "projections of government funds."

Intrinsic factors considered most reliable are "entries into new markets" and "anticipated expansion of plant facilities and/or new acquisitions." One company, essentially a research and development organization, selected "projections of government funds to their company." This same company indicated that their manpower projections would be adversely affected by a 10% decrease in government funds. Such a decrease, they believe, would result in about a 2-3% reduction in their estimates for nuclear degreed individuals and a 9-10% decrease in their estimates for other degreed personnel.

RADIOACTIVE WASTE DISPOSAL

BLS Segment Definition -- The packaging and disposal of radioactive waste materials, including both byproduct and source material wastes. Includes associated research and development activities.

PRESENTATION OF STATISTICAL DATA

In 1968, the sample represented 22.2% of all scientists, engineers and technicians working in this segment as reported by the BLS. The historical BLS data for scientists, engineers, and technicians working in the radioactive waste disposal segment are given below:

Historical BLS Data (1963-1968)

Year	Scientists	Engineers	Technicians	Totals
1963	2	22	51	75
1964	3	5	22	30
1965	7	5	24	36
1966	0	4	29	33
1967	6	1	6	13
1968	5	4	18	27

The sample data was extrapolated by the ANS to the entire radioactive waste disposal segment for 1969, 1970, and 1973. The results are presented in Table 9. The overall growth of technical manpower requirements for companies in this segment of the atomic energy field between July 1969 and December 31, 1973 is 86.2%.

The percent increases between 1969 and 1973 for each of the listed occupational categories are:

Occupational Categories	% Increase Between July 1969 and December 31, 1973	Numerical Increase Between July 1969 and December 31, 1973
Engineers	105.3%	20
Other Technicians	86.2%	50
Health Physics Technicians and Radiation Monitors	76.9%	30

Table 9

– RADIOACTIVE WASTE DISPOSAL –

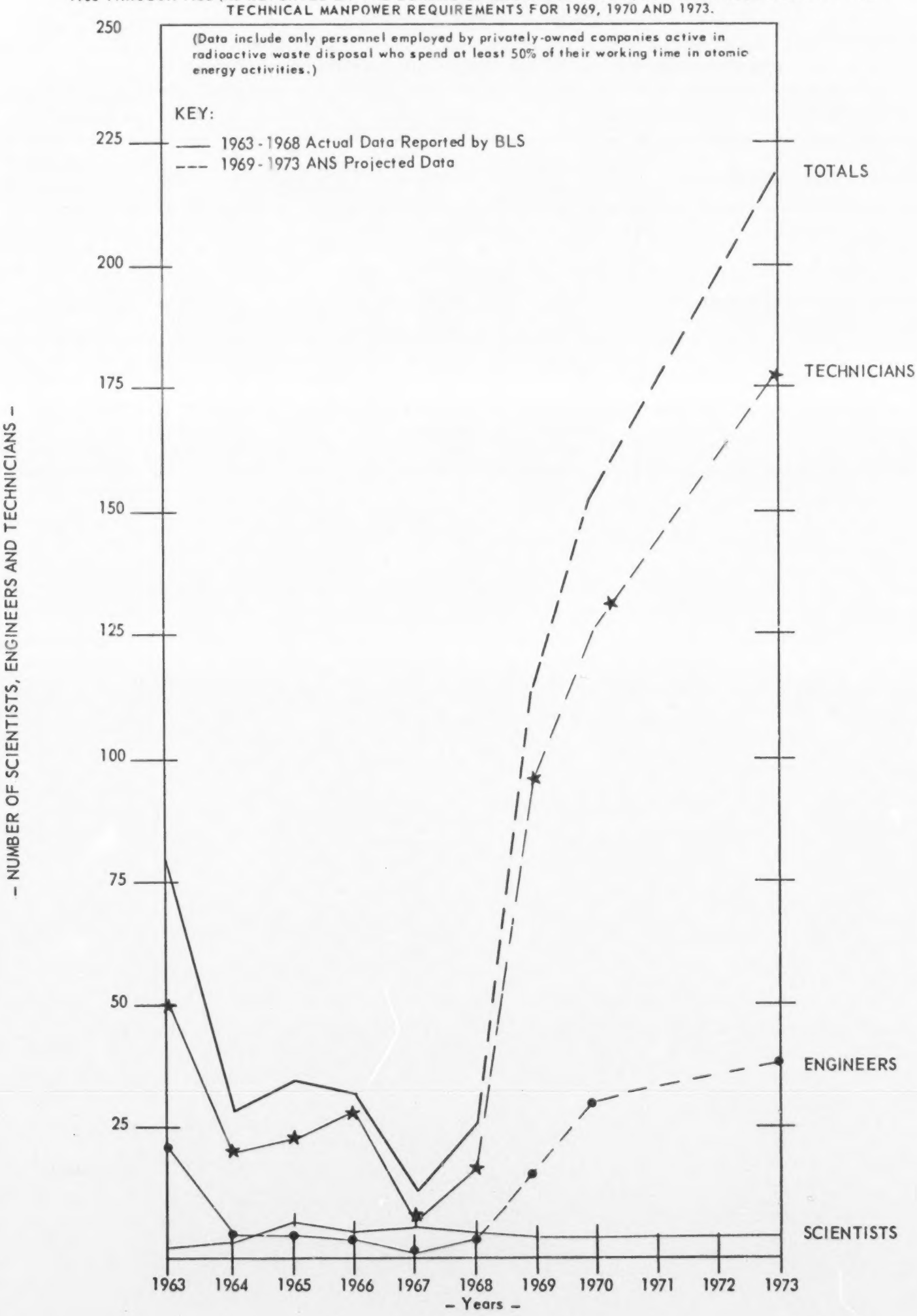
CURRENT (1969) EMPLOYMENT OF SCIENTISTS, ENGINEERS AND TECHNICIANS BY OCCUPATIONAL CATEGORIES AND ANS PROJECTIONS OF TECHNICAL MANPOWER REQUIREMENTS FOR 1970 AND 1973.

(Data include only personnel employed by privately-owned companies active in radioactive waste disposal who spend at least 50% of their working time in atomic energy activities.)

OCCUPATIONAL CATEGORIES	CURRENT EMPLOYMENT	1970	INCREASE/ DECREASE	1973	INCREASE DECREASE
ENGINEERS	(16.7) 19	(17.5) 27	+8	(17.9) 39	+12
HEALTH PHYSICS TECHNICIANS & RADIATION MONITORS	(33.3) 39	(32.5) 50	+11	(32.1) 69	+19
OTHER TECHNICIANS	(50.0) 58	(50.0) 77	+19	(50.0) 108	+31
TOTALS	(100.0) 116	(100.0) 154	+38	(100.0) 216	+62

Chart 10

EMPLOYMENT OF SCIENTISTS, ENGINEERS AND TECHNICIANS BY COMPANIES ACTIVE IN THE RADIOACTIVE WASTE DISPOSAL SEGMENT OF THE PRIVATE SECTOR OF THE ATOMIC ENERGY FIELD FOR EACH YEAR EXTENDING FROM 1963 THROUGH 1968 (AS REPORTED BY THE BUREAU OF LABOR STATISTICS) AND ANS PROJECTIONS OF THE TECHNICAL MANPOWER REQUIREMENTS FOR 1969, 1970 AND 1973.



Technicians make up not only the majority of the currently employed personnel but also the projected technical manpower requirements. The large increase percentagewise in the engineer category is probably related to a desire by these companies to establish more service centers and burial sites throughout the U.S.

Chart 10 represents the actual historical BLS technical manpower data (1963-1968) for the non-government-owned companies active in the radioactive waste disposal segment, and ANS projections of this industry's requirements for technical personnel through 1973.

Nuclear degreed scientists or engineers have not been employed in this segment of the atomic energy field nor do they expect to hire any in the future.

The percentage of currently employed engineers with a particular educational background to the total number of engineers are as follows:

Educational Backgrounds	% of Currently Employed Engineers	Number of Currently Employed Engineers
Chemical Engineering	52.4%	11
Chemistry	21.1%	4
Mechanical Engineering	21.1%	4
TOTALS	100.0%	21

Of the currently employed degreed (non-nuclear) engineers, 78.9% have BS's and 21.1% have PhD's.

SUMMATION OF IN-DEPTH INTERVIEWS

When hiring degreed personnel, experience is considered as the primary employment qualification. This is also true when hiring technician-level personnel. The radioactive waste disposal industry is extremely small and, as a result, it does not have the capability to provide either extensive or formalized training programs for the untrained individual.

RADIOACTIVE WASTE DISPOSAL

Engineers are employed primarily to work in activities associated with installations, operations, and maintenance and management. Technicians, on the other hand, work exclusively in installations, operations, and maintenance activities.

There has been good to excellent success in hiring enough engineers to fill their manpower requirements during the past five years. Furthermore, they do not foresee any difficulty in attracting enough engineers in 1970 or 1973. With regard to the hiring of technicians, there has been only fair to good success.

The technical requirements of this segment of the atomic energy field are such that they do not need the technical sophistication of a nuclear degreed scientist or engineer. However, they would prefer their engineers to have some nuclear training in the areas of radiation shielding, radioisotope techniques, health physics, radiation safety, and instrumentation. Some training or course-work in health physics, radiation safety, and instrumentation is recommended for technicians employed in this segment of the atomic energy field.

In forecasting manpower requirements, emphasis is placed on the "estimated nuclear power plant generating capacities."

NUCLEAR INSTRUMENT MANUFACTURING

BLS Segment Definition -- Reporting units engaged in manufacturing instruments primarily for the atomic energy field, such as accessory instrumentation for reactor controls, radiation detection instruments and hot laboratory equipment, including manipulators.

PRESENTATION OF STATISTICAL DATA

In 1968, the interviewed companies employed 35.8% of all engineers, 51.6% of all scientists, and 31.1% of all technicians working in this segment as reported by BLS. The historical data for scientists, engineers, and technicians employed in the nuclear instrument manufacturing segment (non-government-owned) are given below:

Historical BLS Data (1963-1968)

Year	Scientists	Engineers	Technicians	Totals
1963	219	806	1,004	2,029
1964	236	902	1,296	2,434
1965	279	826	1,166	2,271
1966	320	662	1,350	2,332
1967	233	813	1,437	2,483
1968	186	670	1,199	2,055

Data provided by the sample companies and extrapolated by the ANS to the entire nuclear instrument manufacturing segment (privately owned) for 1969, 1970, and 1973 are presented in Table 10. The overall growth in technical manpower requirements for this segment of the atomic energy field between July, 1969 and December 31, 1973 is 40.2%.

The percent increases between July 1969 and December 31, 1973 for each of the listed occupational categories are:

Table 10

– NUCLEAR INSTRUMENT MANUFACTURING –

CURRENT (1969) EMPLOYMENT OF SCIENTISTS, ENGINEERS AND TECHNICIANS BY OCCUPATIONAL CATEGORIES AND ANS PROJECTIONS OF TECHNICAL MANPOWER REQUIREMENTS FOR 1970 AND 1973.

(Data include only personnel employed by privately-owned companies active in nuclear instrument manufacturing who spend at least 50% of their working time in atomic energy activities.)

OCCUPATIONAL CATEGORIES	CURRENT EMPLOYMENT	1970	INCREASE/ DECREASE	1973	INCREASE/ DECREASE
PHYSICAL SCIENTISTS	180	198	+18	248	+50
LIFE SCIENTISTS	31	37	+6	54	+17
ENGINEERS	681	731	+50	913	+182
MATHEMATICIANS	12	19	+7	25	+6
DRAFTSMEN	120	126	+6	183	+57
ELECTRICAL & ELECTRONICS TECHNICIANS	795	875	+80	1,135	+260
OTHER ENGINEERING TECHNICIANS	53	66	+13	106	+40
HEALTH PHYSICS TECHNICIANS & RADIATION MONITORS	13	12	-1	22	+10
LIFE SCIENCE TECHNICIANS	14	13	-1	26	+13
PHYSICAL SCIENCE TECHNICIANS	185	173	-12	221	+48
OTHER TECHNICIANS	105	106	+1	135	+29
TOTALS	2,189	2,356	+167	3,068	+712

NUCLEAR INSTRUMENT MANUFACTURING

Occupational Categories	% Increase Between July 1969 and December 31, 1973	Numerical Increase Between July 1969 and December 31, 1973
Mathematicians	108.3%	13
Other Engineering Technicians	100.0%	53
Life Science Technicians	85.7%	12
Life Scientists	74.2%	23
Health Physics Technicians & Radiation Monitors	69.2%	9
Draftsmen	52.5%	63
Electrical/Electronics Technicians	42.8%	340
Physical Scientists	37.8%	68
Engineers	34.1%	232
Other Technicians	28.6%	30
Physical Science Technicians	19.5%	36
TOTALS	40.2%	879

Consolidating the above occupational categories into three broad categories of scientists, engineers and technicians, shows the following percent increases between July 1969 and December 31, 1973:

Occupational Categories	% Increase Between July 1969 and December 31, 1973	Numerical Increase Between July 1969 and December 31, 1973
Scientists (Includes Mathematicians)	46.6%	104
Technicians (Includes Draftsmen)	42.3%	543
Engineers	34.1%	232

The scientist category shows the largest percent increase reflecting, perhaps, this segment's entry or greater involvement in the reactor area monitoring

instrumentation and nuclear medicine instrumentation. It is also evident that as their products become commercially available, a greater number of technician-level personnel will be needed for functions such as quality control, installation, maintenance, etc.

Chart 11 represents the actual historical BLS technical manpower data (1963-1968) for the non-government-owned companies active in nuclear instrument manufacturing activities and ANS projections of the industry's requirements for technical manpower through 1973. Only the technician category shows any significant change between the historical and projected data. Both the engineer and scientist categories remain essentially the same between 1963 and 1973.

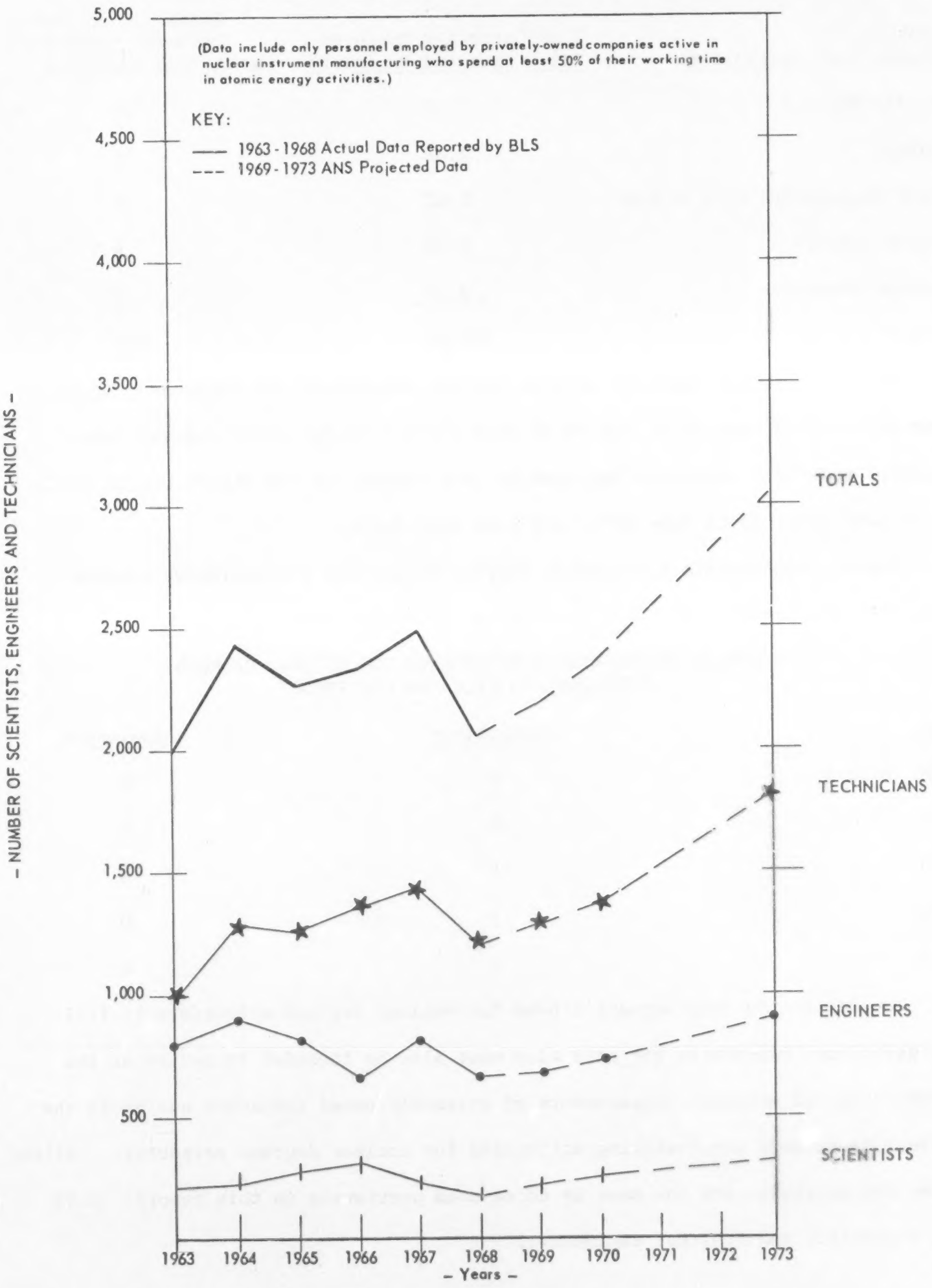
Currently, there are 29 nuclear scientists and 6 nuclear engineers employed by [illegible] privately owned companies active in this segment of the atomic energy field. These companies, however, expect to hire an additional 27 nuclear scientists to fill new positions between 1969 and 1973. None of the companies are planning to hire additional nuclear engineers during this same time period.

Percentages of currently employed scientists and engineers with a particular educational background to the total number of scientists and engineers are as follows:

Educational Backgrounds	% of Currently Employed Scientists and Engineers	Number of Currently Employed Scientists and Engineers
Electrical/Electronics Engineering	52.0%	467
Chemistry	13.0%	117
Mechanical Engineering	10.1%	91
Physics	8.7%	78
Chemical Engineering	4.0%	36
Other Science Disciplines	2.9%	26

Chart 11

EMPLOYMENT OF SCIENTISTS, ENGINEERS AND TECHNICIANS BY COMPANIES ACTIVE IN THE NUCLEAR INSTRUMENT MANUFACTURING SEGMENT OF THE PRIVATE SECTOR OF THE ATOMIC ENERGY FIELD FOR EACH YEAR EXTENDING FROM 1963 THROUGH 1968 (AS REPORTED BY THE BUREAU OF LABOR STATISTICS) AND ANS PROJECTIONS OF THE TECHNICAL MANPOWER REQUIREMENTS FOR 1969, 1970 AND 1973.



(Cont'd) Occupational Categories	% of Currently Employed Scientists and Engineers	Number of Currently Employed Scientists and Engineers
Nuclear Physics	2.4%	20
Biology	2.4%	21
Other Engineering Disciplines	2.4%	21
Health Physics	1.2%	8
Nuclear Chemistry	0.9%	7
TOTALS	100.0%	892

Of the currently employed nuclear degreed scientists and engineers, 18.8% have BS's; 62.5% have MS's; and 18.7% have PhD's. Of the other degreed (non-nuclear) personnel currently employed in this segment of the atomic energy field, 81.5% have BS's; 15.0% have MS's; and 3.5% have PhD's.

Annual requirements for nuclear degreed scientists and engineers between July 1969 and December 31, 1973 to fill new positions are:

ANNUAL INCREMENTAL REQUIREMENTS FOR NUCLEAR DEGREED PERSONNEL TO FILL NEW POSITIONS

Year	Scientists	Engineers
1969 (6 mo.)	4	0
1970	8	0
1971	5	0
1972	5	0
1973	5	0

In addition to this segment's need for nuclear degreed scientists to fill new positions, allowances for attrition must also be included to arrive at the total technical manpower requirements of privately owned companies active in the nuclear instrument manufacturing activities for nuclear degreed personnel. (Allowances for attrition are the same as those used previously in this report: 8.4% for scientists and 7.6% for engineers.)

NUCLEAR INSTRUMENT MANUFACTURING

Year	Nuclear Scientists Growth	Replacement	Totals	Nuclear Engineers Growth	Replacement	Totals
1969 (6 mo.)	4	2	6	0	1	1
1970	8	3	11	0	1	1
1971	5	3	8	0	1	1
1972	5	4	9	0	1	1
1973	5	5	10	0	1	1
TOTALS	27	17	44	0	5	5
Average Annual Incremental Requirements (4½ yrs.)	6.0	3.8	9.8	0.0	1.1	1.1

Between July 1969 and December 31, 1973 a total of 49 nuclear degreed personnel will be needed by all privately owned companies active in the nuclear instrument manufacturing segment. This total requirement averages out to about 11 nuclear degreed scientists and engineers each year to fill new and replacement positions within these organizations.

SUMMATION OF IN-DEPTH INTERVIEWS

These companies evaluate degreed (non-nuclear) scientists in relation to the candidate's education and experience. However, the primary employment qualification for degreed (non-nuclear) engineers is the extent of the candidate's experience in the electronics field. The interviewed companies prefer to hire engineers who can design and develop products. Their primary interest, therefore, is in the applications oriented individual. Level of degree is evaluated only as a means of identifying what the individual is capable of doing. These companies hire very few recent graduates.

Degreed (non-nuclear) scientists and engineers work primarily in company activities associated with technical assistance and consulting (49%). Their remaining degreed employees work in design and development (12%), test and evaluation (9%), research (7%), management (62%), and production (5%) activities.

NUCLEAR INSTRUMENT MANUFACTURING

The interviewed companies have had only fair to good success in filling their needs for qualified degreed (non-nuclear) scientists and engineers. What difficulty they have is attributed to the extremely high salary scales these people are demanding. Probably the only effective selling point these organizations have is the excellent growth potential the scientist or engineer has with small but growing companies.

In the near future, these companies foresee even greater difficulty in filling their requirements for degreed (non-nuclear) personnel. Two of the major reasons given for this anticipated technical manpower shortage are: 1) the reduction in student enrollments in engineering and the concurrent effect of the draft on graduate enrollments, and 2) because of the National Science Foundation's and other government agencies' funding cutbacks, many professors have left, or will probably leave the universities for employment elsewhere, thus affecting the quality of future graduates.

By the early 1970's, these organizations will be hiring a greater number of environmental scientists such as biochemists, biologists, etc. They also expect to hire more engineering specialists -- especially mechanical engineers -- for design and development activities.

The majority of the companies would like their degreed (non-nuclear) scientists and engineers to have some coursework in nuclear science and engineering. This added knowledge can but only add to the organization's overall competency and competitiveness in the nuclear instrumentation field. Some of the nuclear related courses which would be most applicable to the technical environments of these companies are; radiochemistry, instrumentation, radioisotope techniques, nuclear chemistry, health physics, and nuclear physics.

The majority of the interviewed companies have hired nuclear degreed scientists and engineers while the remaining companies have not. For those

companies that have not hired nuclear degreed people, the reasons given were: 1) the company's current product-line does not require the sophisticated knowledge of nuclear technology; 2) they (the companies) consider themselves to be electronics organizations and, the fact that they sell to the nuclear field, is incidental; and, 3) the companies have been successful with a staff composed primarily of electrical/electronics engineers and mechanical engineers and they see no reason for changing. For those companies which have hired nuclear degreed individuals, the reason they do so is because of the contacts the nuclear degreed individual has within the nuclear field and for research conceptualization purposes.

Nuclear degreed personnel work primarily in research, development, test and evaluation, design, and management activities.

These companies have not employed many nuclear degreed scientists and engineers and, therefore, have not had too much difficulty in filling their requirements for these types during the past five years. They do not foresee any difficulty in the near future in attracting nuclear degreed scientists and engineers, although a few of the companies are planning to hire more nuclear degreed individuals. This increased need for nuclear degreed personnel is due to the companies' anticipated involvement in nuclear physics research.

In evaluating the educational training received by nuclear degreed scientists and engineers, these organizations stated that the educational backgrounds of nuclear degreed individuals places too much emphasis on experimental considerations and not enough on what and how things work. They also believe that graduate students should receive more coursework in the environmental sciences.

Regarding the employment of technician-level personnel, these organizations prefer graduates of electronics schools or individuals who have been trained at another electronics company. Technicians need more than just a high school diploma to qualify for employment in this industry.

NUCLEAR INSTRUMENT MANUFACTURING

Most technicians (50%) work in activities associated with installations, operations, and maintenance. Another third of the technicians work in test and evaluation activities. The rest of the technicians work in production, research and development, and data collection, processing, and analysis activities.

All of the interviewed companies have had difficulty hiring qualified technicians during the past five years. In this industry, there is about a 6-8% annual turnover of technician-level personnel. However, they (the companies) are cautiously optimistic regarding the future supply of technicians. If the future supply of technicians should fall short of the demand, these organizations are prepared to expand their "in-house" training programs.

Some of the nuclear science and engineering courses these companies would like their professional technicians to take are; radioisotope techniques, nuclear chemistry, health physics, and nuclear physics.

The three most reliable extrinsic factors these companies consider when projecting their future technical manpower requirements are; the "general economic outlook," "projections of overall government funds," and "possible new applications of atomic energy." The most reliable intrinsic factors are: "sales forecasts," "entries into new markets," "dollar value of shipments," and "projections of government funds to their company."

Although these organizations are somewhat dependent upon government funds, none of them felt that a 10% cutback in government funds to their company would significantly affect their manpower projections for 1970 and 1973. Generally speaking, these companies have expanded their markets to reduce their historical dependency on government funds.

Processing and Packaging Radioisotopes

BLS Segment Definition -- Reporting units primarily engaged in these activities, and in the development and manufacture of shipping containers for isotopes.

PRESENTATION OF STATISTICAL DATA

In 1968, the interviewed companies employed 9.1% of all engineers, 63.4% of all scientists, and 47.0% of all technicians working in this segment as reported by BLS. The historical data for scientists, engineers, and technicians employed in the processing and packaging radioisotopes segment (non-government-owned) are given below:

Historical BLS Data (1963-1968)

Year	Scientists	Engineers	Technicians	Totals
1963	102	25	102	229
1964	118	22	142	282
1965	130	30	186	346
1966	175	28	216	419
1967	228	39	282	549
1968	205	22	251	478

Data provided by the sample companies and extrapolated by the ANS to the entire processing and packaging radioisotopes industry (privately owned) for 1969, 1970, and 1973 are presented in Table 11. The overall growth in technical manpower requirements for this segment of the atomic energy field between July 1969 and December 31, 1973 is 110.5%.

Percentage increases between July 1969 and December 31, 1973 for each of the listed occupational categories are:

Table 11

– PROCESSING AND PACKAGING RADIOISOTOPES –

CURRENT (1969) EMPLOYMENT OF SCIENTISTS, ENGINEERS AND TECHNICIANS BY OCCUPATIONAL CATEGORIES AND ANS PROJECTIONS OF TECHNICAL MANPOWER REQUIREMENTS FOR 1970 AND 1973.

(Data include only personnel employed by privately-owned companies active in processing and packaging radioisotopes who spend at least 50% of their working time in atomic energy activities.)

OCCUPATIONAL CATEGORIES	CURRENT EMPLOYMENT	1970	INCREASE/ DECREASE	1973	INCREASE/ DECREASE
PHYSICAL SCIENTISTS	132	185	+53	239	+54
LIFE SCIENTISTS	117	171	+54	220	+49
ENGINEERS	22	44	+22	81	+37
DRAFTSMEN	–	–	–	3	+3
ELECTRICAL & ELECTRONICS TECHNICIANS	2	4	+2	11	+7
HEALTH PHYSICS TECHNICIANS & RADIATION MONITORS	25	34	+9	49	+15
LIFE SCIENCE TECHNICIANS	49	72	+23	101	+29
PHYSICAL SCIENCE TECHNICIANS	148	210	+62	338	+128
NUCLEAR MATERIALS MANAGERS	–	–	–	–	–
TOTALS	495	720	+225	1,042	+322

PROCESSING AND PACKAGING RADIOISOTOPES

Occupational Categories	% Increase Between July 1969 and December 31, 1973	Numerical Increase Between July 1969 and December 31, 1973
Electrical/Electronics Technicians	450.0%	9
Engineers	268.2%	59
Physical Science Technicians	128.4%	190
Life Science Technicians	106.1%	52
Health Physics Technicians & Radiation Monitors	96.0%	24
Life Scientists	88.0%	103
Physical Scientists	81.1%	107
TOTALS	110.5%	547

Consolidating the above occupational categories into three broad categories of scientists, engineers, and technicians, shows the following percent increases between 1969 and 1973:

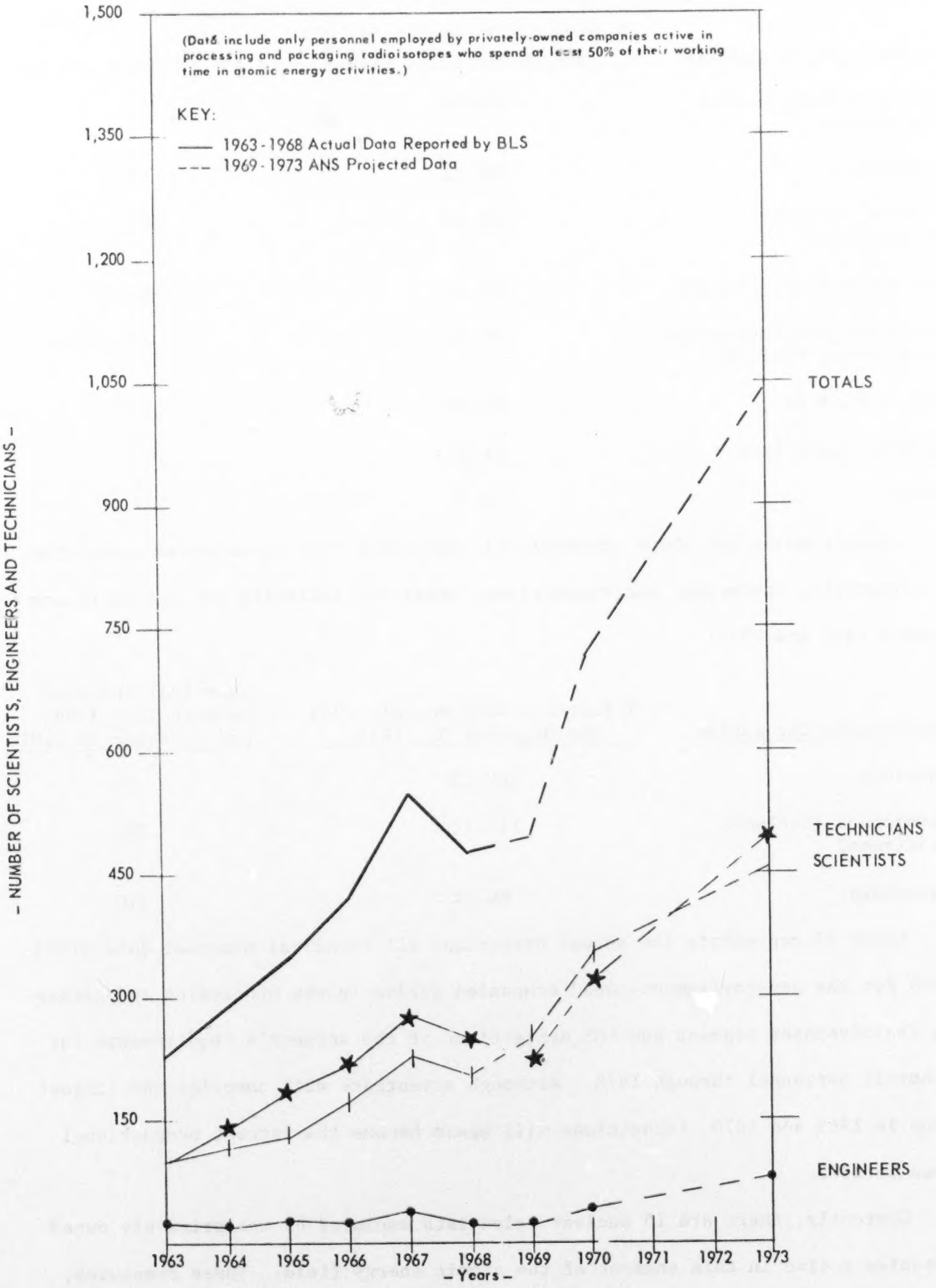
Occupational Categories	% Increase Between July 1969 and December 31, 1973	Numerical Increase Between July 1969 and December 31, 1973
Engineers	268.2%	59
Technicians (Includes Draftsmen)	124.1%	278
Scientists	84.3%	210

Chart 12 represents the actual historical BLS technical manpower data (1963-1968) for the non-government-owned companies active in the processing and packaging radioisotopes segment and ANS projections of the segment's requirements for technical personnel through 1973. Although scientists will comprise the largest group in 1969 and 1970, technicians will again become the largest occupational group by 1973.

Currently, there are 15 nuclear scientists employed by the privately owned companies active in this segment of the atomic energy field. These companies,

Chart 12

EMPLOYMENT OF SCIENTISTS, ENGINEERS AND TECHNICIANS BY COMPANIES ACTIVE IN THE PROCESSING AND PACKAGING RADIOISOTOPES SEGMENT OF THE PRIVATE SECTOR OF THE ATOMIC ENERGY FIELD FOR EACH YEAR EXTENDING FROM 1963 THROUGH 1968 (AS REPORTED BY THE BUREAU OF LABOR STATISTICS) AND ANS PROJECTIONS OF THE TECHNICAL MANPOWER REQUIREMENTS FOR 1969, 1970 AND 1973.



however, expect to hire an additional 21 nuclear scientists and 22 nuclear engineers to fill new positions between 1969 and 1973. The 22 nuclear engineers will be hired during the period extending from January 1, 1971 through 1973.

Percentages of currently employed scientists and engineers with a particular educational background to the total number of currently employed scientists and engineers are as follows:

Educational Backgrounds	% of Currently Employed Scientists and Engineers	Number of Currently Employed Scientists and Engineers
Chemistry	55.3%	151
Biology	20.0%	55
Other Science Disciplines	14.0%	38
Nuclear Chemistry	2.7%	7
Electrical/Electronics Engineering	2.0%	6
Health Physics	2.0%	5
Mechanical Engineering	1.5%	4
Other Nuclear Sciences	1.3%	3
Other Engineering Disciplines	1.2%	2
TOTALS	100.0%	271

Of the currently employed nuclear degreed scientists, 22.3% have BS's; 33.3% have MS's; and, 44.4% have PhD's. Of the other degreed (non-nuclear) personnel currently employed in this segment of the atomic energy field, 68.6% have BS's; 12.9% have MS's; and, 18.5% have PhD's.

The annual requirements for nuclear degreed scientists and engineers between July 1969 and December 31, 1973 to fill new positions are:

PROCESSING AND PACKAGING RADIOISOTOPES

ANNUAL INCREMENTAL REQUIREMENTS FOR NUCLEAR DEGREED PERSONNEL TO FILL NEW POSITIONS

Year	Scientists	Engineers
1969 (6 mo.)	4	0
1970	8	0
1971	3	7
1972	3	7
1973	3	8

In addition to the need for nuclear degreed scientists and engineers to fill new positions, allowances for attrition must also be included to arrive at the total technical manpower requirements of privately owned companies active in the processing and packaging radioisotopes segment for nuclear degreed personnel. (Allowances for attrition are the same as those used previously in this report: 8.4% for scientists and 7.6% for engineers.)

	Nuclear Scientists			Nuclear Engineers		
Year	Growth	Replacement	Totals	Growth	Replacement	Totals
1969 (6 mo.)	4	1	5	0	0	0
1970	8	2	10	0	0	0
1971	3	2	5	7	0	7
1972	3	2	5	7	1	8
1973	3	3	6	8	2	10
TOTALS	21	10	31	22	3	25
Average Annual Incremental Requirements (4½ yrs.)	4.7	2.2	6.9	4.9	0.7	5.6

Between July 1969 and December 31, 1973 a total of 56 nuclear degreed scientists and engineers will be needed by all privately owned companies active in the processing and packaging radioisotopes segment. This total requirement averages out to about 13 nuclear degreed scientists and engineers each year to fill new and

replacement positions within these organizations.

SUMMATION OF IN-DEPTH INTERVIEWS

The primary employment qualification for degreed (non-nuclear) scientists and engineers depends essentially on the nature of the job. However, there seems to be a preference for the experienced individual.

At the majority of the interviewed companies, degreed (non-nuclear) personnel work in research and development, production, scientific and technical information, and management activities. These types also get involved, to a lesser extent, in test and evaluation and standards and specifications activities.

The interviewed companies have had only fair to good success in filling their requirements for degreed (non-nuclear) personnel during the past five years. They also indicated that the supply of scientists during the past year has increased. This increased supply of scientists was attributed to cuts in government research funds which has resulted in many qualified individuals being released from organizations dependent on government funds.

In the near future, these organizations expect the supply of degreed (non-nuclear) scientists and engineers to be tight but feel they will be able to attract their share of the market. One discipline in which there will be a critical shortage is organic chemists both at the BS and PhD levels.

All of the companies were in agreement concerning the relative merits of having their degreed (non-nuclear) personnel take some coursework in nuclear science and engineering. The nuclear related courses which would be most applicable to the companies' technical environment are, nuclear chemistry, radiochemistry, radioisotope techniques, health physics, radiation safety, and instrumentation.

Although these organizations hire very few nuclear degreed scientists and engineers, when they do hire them, they are looking for the experienced individual. Nuclear degreed personnel work almost exclusively in research, production, and management activities.

Generally speaking, the reason why some of these companies hire nuclear degreed scientists and engineers is because of the companies' activity in the nuclear medicine field. The companies generally feel that their health physicists adequately meet the job responsibilities expected of them. However, the companies have found nuclear physicists to be trained almost exclusively for the reactor field, and as a result, they do not readily fit into the technical climate of these organizations.

Technicians employed on the basis of their education and experience work in the areas of research and development, test and evaluation, regulatory enforcement, and data collection, processing, and analysis. These organizations have had, and are having, considerable difficulty in attracting enough technicians to fill their requirements. This shortage is especially acute in the area of nuclear medicine technology.

Nuclear related courses that would benefit their technicians are, nuclear chemistry, radiochemistry, radioisotope techniques, and instrumentation.

The two most reliable extrinsic factors used by these organizations in estimating their technical manpower requirements are, the "general economic outlook" and "possible new applications of atomic energy." Intrinsic factors include, "sales forecasts," "entries into new markets," and "anticipated expansion of plant facilities."

Some of the more general comments offered by the companies were: 1) there should be a greater emphasis placed on nuclear medicine technology not only at

the medical schools, but also at the universities in general; and, 2) college courses should be offered for middle-management personnel to broaden their understanding of the theory and application of radioisotopes.

PARTICLE ACCELERATOR MANUFACTURING

BLS Segment Definition -- Includes the manufacture of particle accelerators and of components specifically designed for and unique to accelerators.

PRESENTATION OF STATISTICAL DATA

In 1968, the interviewed companies employed 39.7% of all engineers, 48.2% of all scientists, and 45.4% of all technicians working in this segment as reported by BLS. The historical data for scientists, engineers, and technicians employed in the particle accelerator manufacturing industry (non-government-owned) are given below:

Historical BLS Data (1963-1968)

Year	Scientists	Engineers	Technicians	Totals
1963	120	197	332	649
1964	77	213	311	601
1965	74	160	268	502
1966	76	190	278	544
1967	72	176	280	528
1968	56	141	271	468

Data provided by the sample companies and extrapolated by the ANS to the entire particle accelerator manufacturing segment (privately owned) for 1969, 1970, and 1973 are presented in Table 12. The overall growth in technical manpower requirements for this segment of the atomic energy field between July 1969 and December 31, 1973 is 46.9%.

Percentage increases between 1969 and 1973 for each of the listed occupational categories are:

Table 12

– PARTICLE ACCELERATOR MANUFACTURING –

CURRENT (1969) EMPLOYMENT OF SCIENTISTS, ENGINEERS AND TECHNICIANS BY OCCUPATIONAL CATEGORIES AND ANS PROJECTIONS OF TECHNICAL MANPOWER REQUIREMENTS FOR 1970 AND 1973.

(Data include only personnel employed by privately-owned companies active in particle accelerator manufacturing who spend at least 50% of their working time in atomic energy activities.)

OCCUPATIONAL CATEGORIES	CURRENT EMPLOYMENT	1970	INCREASE/ DECREASE	1973	INCREASE/ DECREASE
PHYSICAL SCIENTISTS	56	59	+3	67	+8
LIFE SCIENTISTS	2	2	–	3	+1
ENGINEERS	164	192	+28	245	+53
MATHEMATICIANS	6	6	–	8	+2
DRAFTSMEN	63	75	+12	97	+22
ELECTRICAL & ELECTRONICS TECHNICIANS	58	68	+10	85	+17
OTHER ENGINEERING TECHNICIANS	203	240	+37	305	+65
HEALTH PHYSICS TECHNICIANS & RADIATION MONITORS	17	19	+2	26	+7
TOTALS	**569**	**661**	**+92**	**836**	**+175**

PARTICLE ACCELERATOR MANUFACTURING

Occupational Categories	% Increase Between July 1969 and December 31, 1973	Numerical Increase Between July 1969 and December 31, 1973
Draftsmen	54.0%	34
Health Physics Technicians & Radiation Monitors	52.9%	9
Other Technicians	50.2%	102
Life Scientists	50.0%	1
Engineers	49.4%	81
Electrical/Electronics Technicians	46.6%	27
Mathematicians	33.3%	2
Physical Scientists	19.6%	11
TOTALS	46.9%	267

Consolidating the above occupational categories into three broad categories of scientists, engineers, and technicians, shows the following percent increases between July 1969 and December 31, 1973:

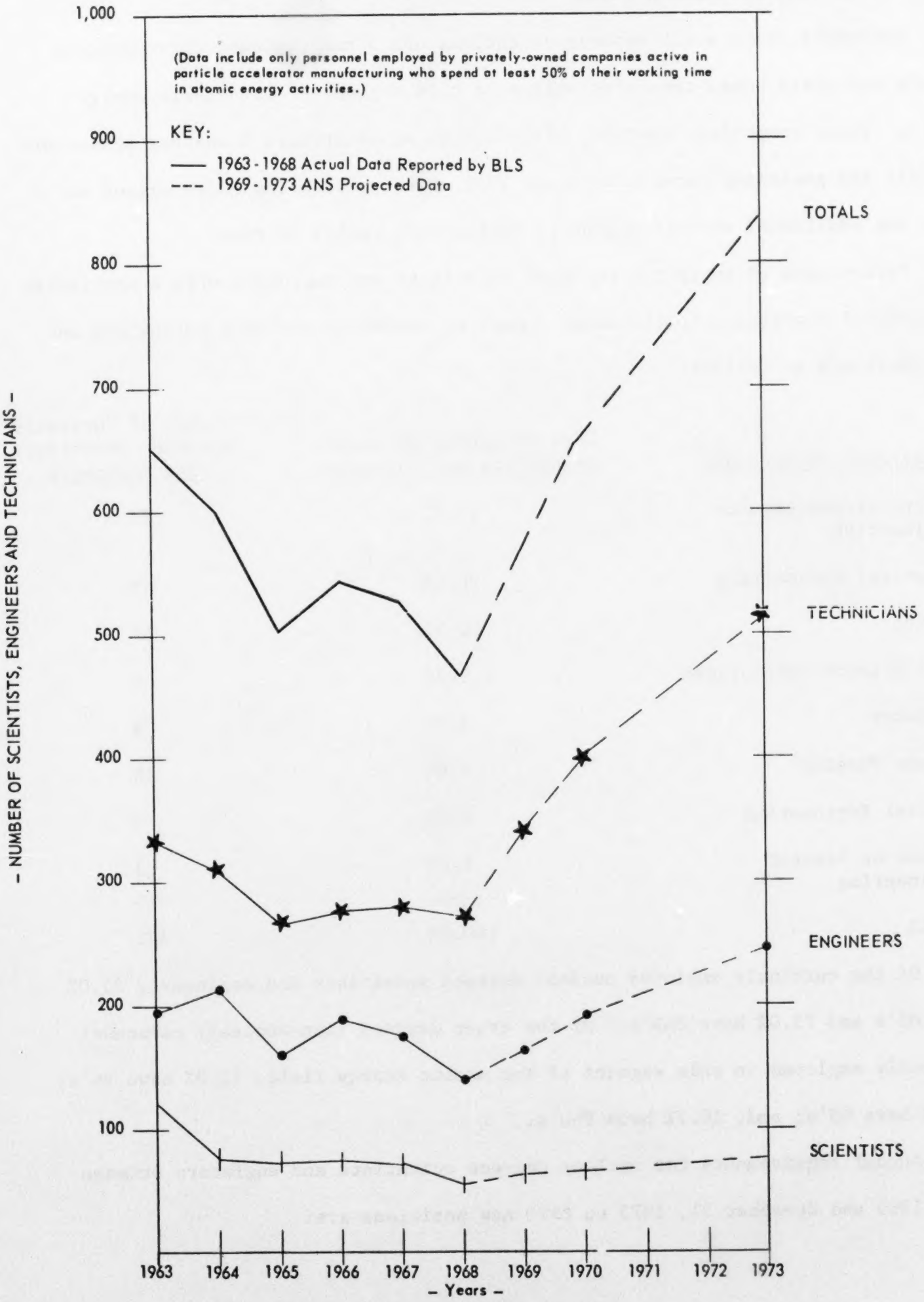
Occupational Categories	% Increase Between July 1969 and December 31, 1973	Numerical Increase Between July 1969 and December 31, 1973
Technicians	50.4%	172
Engineers	49.4%	81
Scientists	21.9%	14

With the increase in engineers and especially technicians, it would seem that this industry is becoming less research and more product oriented.

Chart 13 represents the actual historical BLS technical manpower data (1963-1968) for the entire non-government-owned companies active in particle accelerator manufacturing and ANS projections of the segment's requirements for technical personnel through 1973. Projected requirements for scientists will remain relatively stable, while both the engineer and technician categories will reverse

Chart 13

EMPLOYMENT OF SCIENTISTS, ENGINEERS AND TECHNICIANS BY COMPANIES ACTIVE IN THE PARTICLE ACCELERATOR MANUFACTURING SEGMENT OF THE PRIVATE SECTOR OF THE ATOMIC ENERGY FIELD FOR EACH YEAR EXTENDING FROM 1963 THROUGH 1968 (AS REPORTED BY THE BUREAU OF LABOR STATISTICS) AND ANS PROJECTIONS OF THE TECHNICAL MANPOWER REQUIREMENTS FOR 1969, 1970 AND 1973.



their previously decreasing trend.

Currently there are 8 nuclear scientists and 3 nuclear engineers employed by the privately owned companies active in this segment of the atomic energy field. These companies, however, plan to hire an additional 6 nuclear scientists to fill new positions between 1970 and 1973. None of the companies expect to hire any additional nuclear engineers during this period of time.

Percentages of currently employed scientists and engineers with a particular educational background to the total number of currently employed scientists and engineers are as follows:

Educational Backgrounds	% of Currently Employed Scientists and Engineers	Number of Currently Employed Scientists and Engineers
Electrical/Electronics Engineering	29.2%	87
Mechanical Engineering	26.6%	59
Physics	20.3%	45
Other Science Disciplines	3.9%	9
Chemistry	3.8%	8
Nuclear Physics	3.8%	8
Chemical Engineering	1.2%	3
Nuclear or Reactor Engineering	1.2%	3
TOTALS	100.0%	222

Of the currently employed nuclear degreed scientists and engineers, 25.0% have MS's and 75.0% have PhD's. Of the other degreed (non-nuclear) personnel currently employed in this segment of the atomic energy field, 72.0% have BS's; 17.3% have MS's; and, 10.7% have PhD's.

Annual requirements for nuclear degreed scientists and engineers between July 1969 and December 31, 1973 to fill new positions are:

ANNUAL INCREMENTAL REQUIREMENTS FOR NUCLEAR DEGREED PERSONNEL TO FILL NEW POSITIONS

Year	Scientists	Engineers
1969 (6 mo.)	0	0
1970	0	0
1971	2	0
1972	2	0
1973	2	0

In addition to the need for nuclear degreed scientists to fill new psoitions, allowances for attrition must also be included to arrive at the total technical manpower requirements of privately owned companies active in the particle accelerator manufacturing segment for nuclear degreed personnel. (Allowances for attrition are the same as those used previously in this report: 8.4% for scientists and 7.6% for engineers.)

	Nuclear Scientists			Nuclear Engineers		
Year	Growth	Replacement	Totals	Growth	Replacement	Totals
1969 (6 mo.)	0	1	1	0	0	0
1970	0	1	1	0	0	0
1971	2	1	3	0	0	0
1972	2	1	3	0	0	0
1973	2	1	3	0	0	0
TOTALS	6	5	11	0	0	0
Average Annual Incremental Requirements (4½ yrs.)	1.3	1.1	2.4	-	-	-

Between July 1969 and December 31, 1973 a total of 11 nuclear scientists will be needed by all privately owned companies active in the particle accelerator manufacturing segment. This total requirement averages out to about 2 nuclear scientists each year to fill new and replacement positions within these organizations.

PARTICLE ACCELERATOR MANUFACTURING

SUMMATION OF IN-DEPTH INTERVIEWS

Generally speaking, these companies hire a scientist or engineer for the specific skills he possesses.

Degreed (non-nuclear) scientists and engineers work primarily in development, test and evaluation, design, and production activities.

During the past five years, the interviewed companies have had good success in filling their requirements for degreed (non-nuclear) scientists and engineers. Some of the reasons for their success are: 1) the company's reputation; 2) the company's geographical location; and, 3) the challenges and opportunities available to their employees. These organizations were also optimistic about filling their needs for degreed (non-nuclear) personnel in 1970 and 1973. However, they also believe it will be more difficult for them to hire qualified individuals.

The companies indicated they would like their degreed (non-nuclear) scientists and engineers to have some coursework in nuclear science and engineering. They believe such coursework would give their employees a better understanding of new nuclear applications of their products. Specifically, they would like to hire chemical engineers and/or process engineers who have had some background training in radiation chemistry. Some of the nuclear related courses these companies would like their degreed (non-nuclear) personnel to take are, radiation shielding, radiological physics, radiation safety, and instrumentation.

None of the interviewed companies anticipate, in the near future, any change in emphasis on hiring degreed (non-nuclear) scientists and engineers with a particular educational background as compared to their current hiring practices. They will continue to emphasize electrical/electronics and mechanical engineers, chemists and physicists.

These companies will hire very few nuclear degreed scientists by 1970 or 1973. Those they do hire will be hired specifically to make the company

competitive in the nuclear field. They see the nuclear degreed individual as a means to develop new applications of their products.

The reason why these companies do not hire a greater number of nuclear degreed scientists and engineers is because the companies are now emphasizing product development rather than basic research. As a result, they need personnel trained in a number of basic engineering disciplines. The companies believe the experienced chemical, mechanical and electrical engineer is their most valued possession.

The companies that plan to hire nuclear degreed scientists in 1971, 1972 and 1973 expect no difficulty in filling their requirements.

When hiring technicians, these organizations look for people who have had some specialized technological training. Technicians at these organizations work in activities associated with development, design, construction and installations, operations, and maintenance.

Employment of technicians has been difficult for all the interviewed companies during the past five years. One company indicated that in order for it to overcome the tight technician market, they have developed "in-house" training programs. The only nuclear course these companies believe would be of value to their technicians is radioisotope techniques.

Some of the general comments made by these organizations were: 1) at the graduate nuclear science level, more emphasis should be placed on process engineering (specifically, relating radiation sources to the process line); 2) too much money is spent on reactor technology at the universities and national labs, and not enough is directed toward the development of radiation applications for manufacturing and industrial organizations; and, 3) a common dilemma experienced not only by these organizations but also by virtually all of the interviewed companies is that their marketing personnel lack sufficient technical education while their technically oriented personnel are not good businessmen!

PARTICLE ACCELERATOR MANUFACTURING

The extrinsic factor which has proven to be the most reliable measure of these organizations' technical manpower requirements is "possible new applications of atomic energy." The two main intrinsic factors are "sales forecasts" and "entries into new markets."

PRIVATE RESEARCH LABORATORIES

BLS Segment Definition -- Private laboratories engaged in research-development and other testing facilities in connection with atomic energy work.

PRESENTATION OF STATISTICAL DATA

In 1968, the interviewed companies employed 23.1% of all engineers, 22.7% of all scientists, and 25.5% of all technicians working in this segment as reported by BLS. The historical BLS data for scientists, engineers, and technicians employed at private research laboratories (non-government-owned) are given below:

Historical BLS Data (1963-1968)

Year	Scientists	Engineers	Technicians	Totals
1963	429	414	609	1,452
1964	776	617	925	2,318
1965	870	687	1,171	2,728
1966	745	713	1,072	2,530
1967	683	647	765	2,095
1968	648	658	835	2,141

Data provided by the sample companies and extrapolated by the ANS to the entire private research laboratories (privately owned) for 1969, 1970, and 1973 are presented in Table 13. The overall growth in technical manpower requirements for this segment of the atomic energy field between July 1969 and December 31, 1973 is 33.9%.

Percentage increases between July 1969 and December 31, 1973 for each of the listed occupational categories are:

Occupational Categories	% Increase Between July 1969 and December 31, 1973	Numerical Increase Between July 1969 and December 31, 1973
Life Scientists	84.5%	49
Draftsmen	76.8%	43

Table 13

– PRIVATE RESEARCH LABORATORIES –

CURRENT (1969) EMPLOYMENT OF SCIENTISTS, ENGINEERS AND TECHNICIANS BY OCCUPATIONAL CATEGORIES AND ANS PROJECTIONS OF TECHNICAL MANPOWER REQUIREMENTS FOR 1970 AND 1973.

(Data include only personnel employed by privately-owned companies active in private research laboratories who spend at least 50% of their working time in atomic energy activities.)

OCCUPATIONAL CATEGORIES	CURRENT EMPLOYMENT	1970	INCREASE/ DECREASE	1973	INCREASE/ DECREASE
PHYSICAL SCIENTISTS	732	817	+85	976	+159
LIFE SCIENTISTS	58	80	+22	107	+27
ENGINEERS	1,300	1,476	+176	1,712	+236
MATHEMATICIANS	62	71	+9	93	+22
DRAFTSMEN	56	71	+15	99	+28
ELECTRICAL & ELECTRONICS TECHNICIANS	284	332	+48	417	+85
OTHER ENGINEERING TECHNICIANS	474	536	+62	593	+57
HEALTH PHYSICS TECHNICIANS & RADIATION MONITORS	20	19	–1	32	+13
LIFE SCIENCE TECHNICIANS	–	10	+10	24	+14
PHYSICAL SCIENCE TECHNICIANS	290	318	+28	347	+29
OTHER TECHNICIANS	53	57	+4	80	+23
NUCLEAR REACTOR OPERATORS	104	109	+5	109	–
NUCLEAR MATERIALS MANAGERS	–	5	+5	7	+2
TOTALS	**3,433**	**3,901**	**+468**	**4,596**	**+695**

PRIVATE RESEARCH LABORATORIES

(Cont'd) Occupational Categories	% Increase Between July 1969 and December 31, 1973	Numerical Increase Between July 1969 and December 31, 1973
Health Physics Technicians & Radiation Monitors	60.0%	12
Other Technicians	50.9%	27
Mathematicians	50.0%	31
Electrical/Electronics Technicians	46.8%	133
Physical Scientists	33.3%	244
Engineers	31.7%	412
Other Engineering Technicians	25.1%	119
Physical Science Technicians	19.7%	57
Nuclear Reactor Operators	4.8%	5
Life Science Technicians	---	24
Nuclear Materials Managers	---	7
TOTALS	33.9%	1,163

With the increased concern over environmental problems, it is interesting to see that the private research organizations are building up their competency in the life sciences while maintaining their staff level in the physical sciences. Consolidating the above occupational categories into three broad categories of scientists, engineers, and technicians, shows the following percent increases between 1969 and 1973:

Occupational Categories	% Increase Between July 1969 and December 31, 1973	Numerical Increase Between July 1969 and December 31, 1973
Scientists (Includes Mathematicians)	38.0%	324
Technicians (Includes Draftsmen, Nuclear Reactor Operators and Nuclear Materials Managers)	33.3%	427
Engineers	31.7%	412

PRIVATE RESEARCH LABORATORIES

Chart 14 represents the actual historical BLS technical manpower data (1963-1968) for non-government-owned organizations classified as private research laboratories and ANS projections of their requirements for technical personnel through 1973.

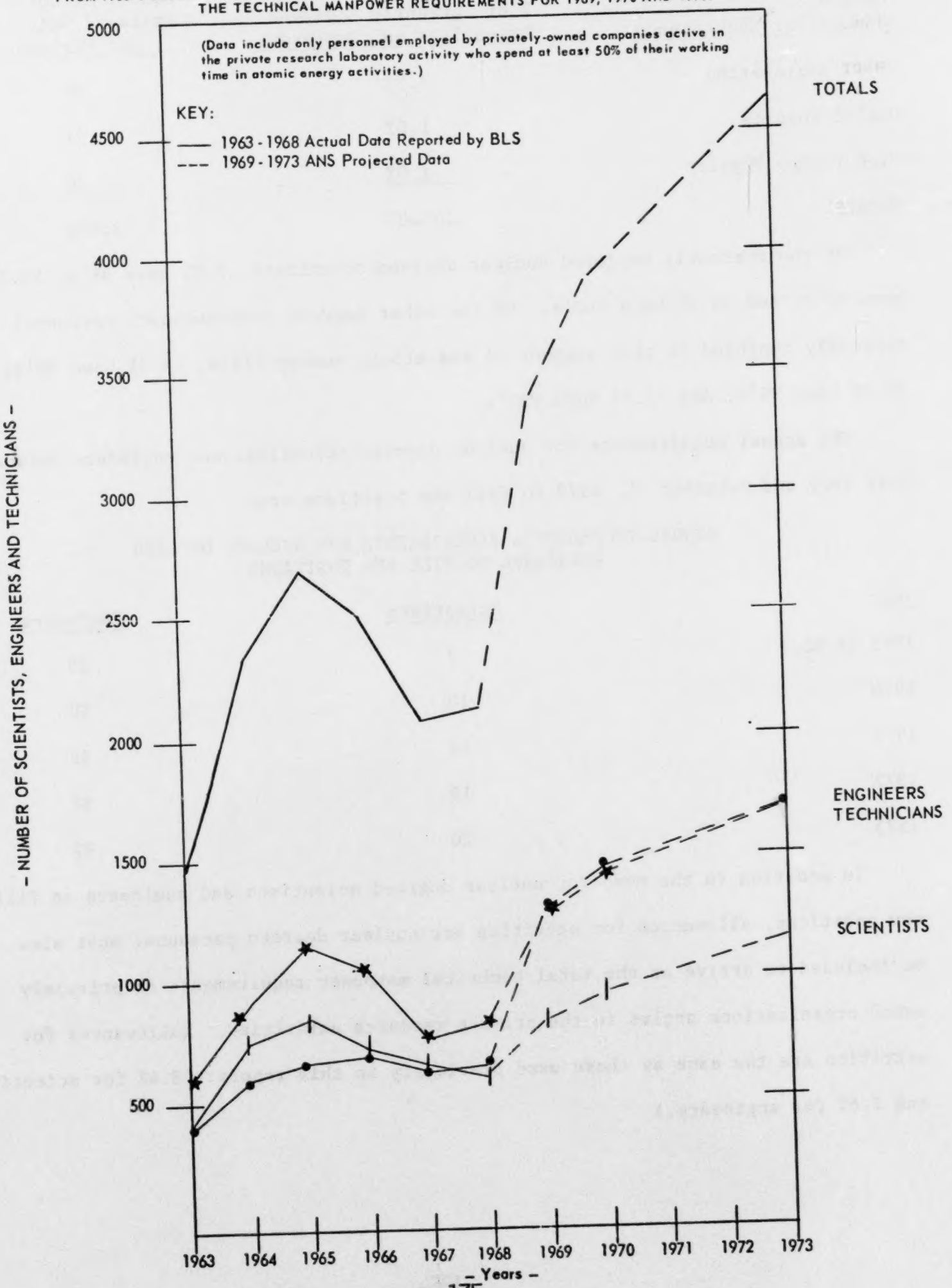
Currently, there are 142 nuclear scientists and 310 nuclear engineers employed by the privately owned organizations active in this segment of the atomic energy field. These companies, however, expect to hire an additional 80 nuclear scientists and 171 nuclear engineers to fill new positions between 1969 and 1973.

Percentages of currently employed scientists and engineers with a particular educational background to the total number of currently employed scientists and engineers are as follows:

Educational Backgrounds	% of Currently Employed Scientists and Engineers	Number of Currently Employed Scientists and Engineers
Physics	23.5%	490
Nuclear or Reactor Engineers	14.4%	306
Mechanical Engineering	13.6%	283
Metallurgical Engineering	8.7%	180
Electrical/Electronics Engineering	8.7%	180
Metallurgy	8.0%	165
Chemistry	5.6%	118
Chemical Engineering	3.8%	79
Nuclear Physics	3.1%	65
Other Engineering Disciplines	2.1%	44
Nuclear Chemistry	1.9%	40
Biology	1.9%	39
Other Science Disciplines	1.5%	31

Chart 14

EMPLOYMENT OF SCIENTISTS, ENGINEERS AND TECHNICIANS BY ORGANIZATIONS ACTIVE IN THE PRIVATE RESEARCH LABORATORIES SEGMENT OF THE PRIVATE SECTOR OF THE ATOMIC ENERGY FIELD FOR EACH YEAR EXTENDING FROM 1963 THROUGH 1968 (AS REPORTED BY THE BUREAU OF LABOR STATISTICS) AND ANS PROJECTIONS OF THE TECHNICAL MANPOWER REQUIREMENTS FOR 1969, 1970 AND 1973.



(Cont'd) Educational Backgrounds	% of Currently Employed Scientists and Engineers	Number of Currently Employed Scientists and Engineers
Civil Engineering	1.2%	29
Health Physics	1.0%	21
High Energy Physics	1.0%	20
TOTALS	100.0%	2,090

Of the currently employed nuclear degreed scientists, 7.8% have BS's, 53.3% have MS's; and 38.9% have PhD's. Of the other degreed (non-nuclear) personnel currently employed in this segment of the atomic energy field, 44.2% have BS's; 32.3% have MS's; and 23.5% have PhD's.

The annual requirements for nuclear degreed scientists and engineers between July 1969 and December 31, 1973 to fill new positions are:

ANNUAL INCREMENTAL REQUIREMENTS FOR NUCLEAR DEGREED PERSONNEL TO FILL NEW POSITIONS

Year	Scientists	Engineers
1969 (6 mo.)	7	25
1970	15	50
1971	19	32
1972	19	32
1973	20	32

In addition to the need for nuclear degreed scientists and engineers to fill new positions, allowances for attrition for nuclear degreed personnel must also be included to arrive at the total technical manpower requirements of privately owned organizations active in the private research activities. (Allowances for attrition are the same as those used previously in this report: 8.4% for scientists and 7.6% for engineers.)

PRIVATE RESEARCH LABORATORIES

Year	Nuclear Scientists			Nuclear Engineers		
	Growth	Replacement	Totals	Growth	Replacement	Totals
1969 (6 mo.)	7	12	19	25	24	49
1970	15	14	29	50	29	79
1971	19	15	34	32	31	63
1972	19	17	36	32	34	66
1973	20	19	39	32	37	69
TOTALS	80	77	157	171	155	326
Average Annual Incremental Requirements (4½ yrs.)	17.8	17.1	34.9	38.0	34.4	72.4

Between July 1969 and December 31, 1973 a total of 483 nuclear degreed scientists and engineers will be required by private research laboratories. This total requirement averages out to slightly more than 107 nuclear degreed scientists and engineers each year to fill new and replacement positions within these organizations.

SUMMATION OF IN-DEPTH INTERVIEWS

The interviewed organizations offered a number of opinions regarding the employment qualifications they consider when hiring a degreed (non-nuclear) scientist or engineer. Some of the employment qualifications they use are: 1) the quality of the man as determined by the candidate's interview with supervisory personnel; 2) determination of how the individual is structured -- first, his ability to see the sponsor's need and, secondly, his problem-solving ability; and, 3) the relationship between the qualifications of the individual and the organization's field of interest. When evaluating potential engineers, the approach is basically the same as that for scientists although there is less emphasis on advanced degreed people.

PRIVATE RESEARCH LABORATORIES

The activities in which their degreed (non-nuclear) scientists and engineers work include, research, research contract and grant administration, development, standards and specifications, scientific and technical information, data collection, processing and analysis, planning, management, and technical assistance and consulting.

All interviewed organizations have had good to excellent success in filling their need for degreed (non-nuclear) scientists and engineers during the past five years. They also expect the supply of degreed (non-nuclear) personnel to be large enough in 1970 and 1973 to meet their requirements. These organizations attribute their success in attracting qualified individuals to the intellectually stimulating work environment found at research laboratories. It is interesting to note that the technical manpower needs of research labs fluctuate considerably. The nature of the business results in a high turnover rate which reflects the changing requirements of their sponsors (i.e., an increased emphasis in an area of technology different from that in which the lab is currently working). This results in the hiring of scientists and engineers who have the required expertise to perform the research related to the sponsor's need.

Whatever difficulty these organizations experience in attracting qualified technical personnel is usually related to the fact that they are looking for very specialized people for very specialized research. Obviously, there is a limited supply of these specialists from which they can draw. One organization indicated that it is having difficulty finding a man trained in radiochemistry. They have been unable to find a radiochemist with any long-term practical experience. Furthermore, they cannot find men with industrial experience who qualify because most industrial people are not "up-to-date" with regard to the latest scientific and technological techniques.

Obviously, these organizations would prefer their degreed (non-nuclear) scientists and engineers to have some nulcear related coursework. Nuclear courses which would have applicability to these organizations are, waste disposal, radiation shielding, nuclear metallurgy, nuclear chemistry, radiochemistry, radioisotope techniques, health physics, control and telemetry, radiation safety, and instrumentation. Research organizations would also like their scientists and engineers to have more coursework and/or experience in the life and social sciences.

The same general employment considerations are followed when hiring a scientist or engineer with a nuclear degree as are followed when hiring scientists and engineers in general. Nuclear degreed personnel work primarily in research, development, test and evaluation and data collection, processing, and analysis activities.

All the interviewed companies have had good success in hiring nuclear degreed individuals. They also do not expect any difficulty in the near future. Again, they attribute their success to the stimulating environment of research laboratories. Their requirements for nuclear degreed scientists and engineers have increased during the past five years and will continue into the seventies. This emphasis on nuclear degreed individuals is probably due to the fact that many sponsors have become more accustomed to "farming out" their research than expanding their own in-house capability.

Generally speaking, these organizations hire nuclear scientists and engineers for nuclear related research currently being conducted by the laboratory. In other words, they hire a specialist to conduct research in a specialized technological field. It is also interesting to note, however, that these organizations believe that a good physicist, for example, or electrical engineer specializing in fast electronics tends to do the required work as well as the nuclear degreed individual.

PRIVATE RESEARCH LABORATORIES

In evaluating the education received by nuclear degreed individuals, the comments offered were: 1) people in the nuclear field do not have an appreciation for ecology and other environmental considerations; 2) the education and training of nuclear scientists and engineers are about as good as any other discipline; 3) more emphasis should be placed on heat transfer and fluid flow for graduate nuclear engineers; 4) the BS degree in nuclear engineering is definitely not needed; and, 5) all professional employees, regardless of their educational background, should have more exposure to business economics.

Employment of technicians at these organizations is based upon the candidate's education and previous experience. Technicians typically work in research, development, design, test and evaluation, data collection, processing and analysis, standards and specifications, and technical assistance activities. Most technicians work in research and development activities.

These organizations do not anticipate any difficulty in filling their requirements for technicians in 1970 or 1973. Nuclear related courses for technicians would include, instrumentation, radioisotope techniques, health physics, radiation safety and fuel handling.

The two extrinsic factors used by these organizations in making manpower projections are, "projections of government funds" and "increasing nuclear power plant generating capacities." The primary intrinsic factors used are "projections of government funds to their company," "dollar value of services," and, "forecasts of research expenditures."

A ten percent decrease in government funds from their current level would not adversely affect their manpower levels. They believe that to have any significant effect, there would have to be at least a twenty-five to thirty percent cutback in government research funds.

INDUSTRIAL RADIOGRAPHY

BLS Segment Definition -- Reporting units primarily engaged in providing commercial radiographic service. Excludes in-plant radiography where its use is incidental to another activity such as manufacturing.

PRESENTATION OF STATISTICAL DATA

In 1968, the interviewed companies employed 70.8% of all engineers, 13.9% of all scientists, and 48.8% of all technicians working in this segment as reported by the BLS. The historical BLS data for scientists, engineers, and technicians working in the industrial radiography segment are given below:

Historical BLS Data (1963-1968)

Year	Scientists	Engineers	Technicians	Totals
1963	4	34	532	570
1964	8	48	546	602
1965	8	49	475	532
1966	6	44	434	484
1967	3	53	434	490
1968	4	48	408	460

Data provided by the sample companies and extrapolated by the ANS to the entire industrial radiography industry for 1969, 1970, and 1973 are presented in Table 14. The overall growth of technical manpower requirements for the companies in this segment of the atomic energy field between July 1969 and December 31, 1973 is 44.6%.

Percentage increases between July 1969 and December 31, 1973 for each of the listed occupational categories are:

Table 14

– INDUSTRIAL RADIOGRAPHY –

CURRENT (1969) EMPLOYMENT OF SCIENTISTS, ENGINEERS AND TECHNICIANS BY OCCUPATIONAL CATEGORIES AND ANS PROJECTIONS OF TECHNICAL MANPOWER REQUIREMENTS FOR 1970 AND 1973.

(Data include only personnel employed by privately-owned companies active in industrial radiography who spend at least 50% of their working time in atomic energy activities.)

OCCUPATIONAL CATEGORIES	CURRENT EMPLOYMENT	1970	INCREASE/ DECREASE	1973	INCREASE/ DECREASE
PHYSICAL SCIENTISTS	4	4	–	8	+4
ENGINEERS	53	62	+9	77	+15
OTHER ENGINEERING TECHNICIANS	15	16	+1	23	+7
OTHER TECHNICIANS	379	455	+76	544	+89
TOTALS	451	537	+86	652	+115

INDUSTRIAL RADIOGRAPHY

Occupational Categories	% Increase Between July 1969 and December 31, 1973	Numerical Increase Between July 1969 and December 31, 1973
Physical Scientists	100.0%	4
Other Engineering Technicians	53.3%	8
Engineers	45.3%	24
Other Technicians	43.5%	165

Consolidating the above occupational categories into three broad categories of scientists, engineers, and technicians, shows the following percentage of increase between July 1969 and December 31, 1973:

Occupational Categories	% Increase Between July 1969 and December 31, 1973	Numerical Increase Between July 1969 and December 31, 1973
Scientists	100.0%	4
Engineers	45.3%	24
Technicians	43.9%	173

It is obvious that this segment of the atomic energy field is comprised primarily of technician-level personnel. Although requirements for technicians are growing at a rate less than either the scientist or engineer categories, they do make up the majority of industrial radiography personnel.

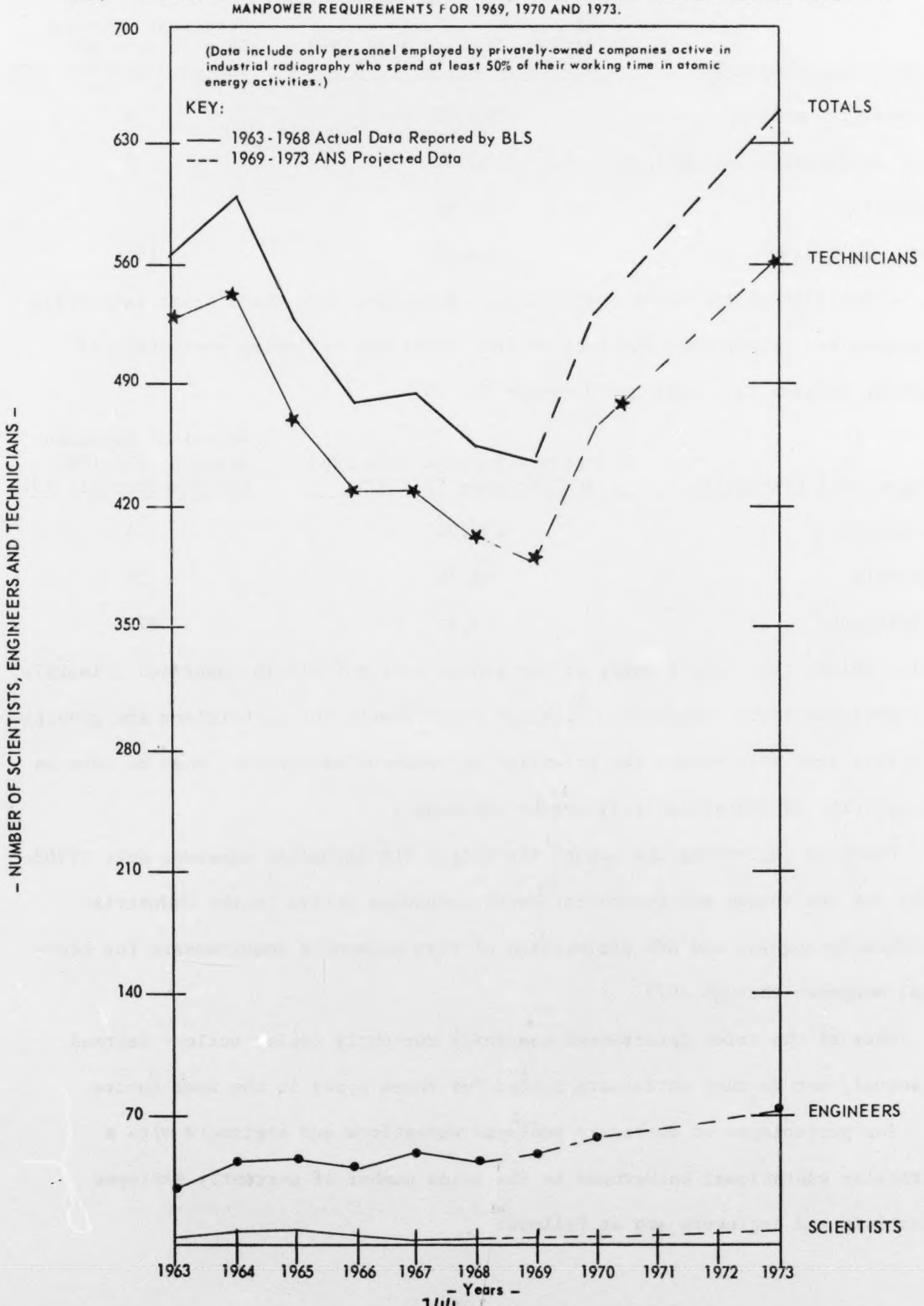
Chart 15 represents the actual historical BLS technical manpower data (1963-1968) for the entire non-government-owned companies active in the industrial radiography segment and ANS projections of this segment's requirements for technical manpower through 1973.

None of the three interviewed companies currently employ nuclear degreed personnel, nor do they anticipate a need for these types in the near future.

The percentages of currently employed scientists and engineers with a particular educational background to the total number of currently employed scientists and engineers are as follows:

Chart 15

EMPLOYMENT OF SCIENTISTS, ENGINEERS AND TECHNICIANS BY COMPANIES ACTIVE IN THE INDUSTRIAL RADIOGRAPHY SEGMENT OF THE PRIVATE SECTOR OF THE ATOMIC ENERGY FIELD FOR EACH YEAR EXTENDING FROM 1963 THROUGH 1968 (AS REPORTED BY THE BUREAU OF LABOR STATISTICS) AND ANS PROJECTIONS OF THE TECHNICAL MANPOWER REQUIREMENTS FOR 1969, 1970 AND 1973.



INDUSTRIAL RADIOGRAPHY

Educational Backgrounds	% of Currently Employed Scientists and Engineers	Number of Currently Employed Scientists and Engineers
Chemical Engineering	29.4%	17
Other Engineering Disciplines	29.4%	17
Electrical/Electronics Engineering	14.7%	8
Mechanical Engineering	11.8%	7
Metallurgical Engineering	11.8%	7
Chemistry	2.9%	1
TOTALS	100.0%	57

Of the currently employed degreed (non-nuclear) scientists and engineers, 91.2% have BS's, and 8.8% have MS's.

SUMMATION OF IN-DEPTH INTERVIEWS

The interviewed companies indicated that experience was the primary employment qualification they consider when evaluating potential degreed (non-nuclear) employees. Their degreed (non-nuclear) personnel work primarily in planning, management, technical assistance, and consulting activities.

During the past five years, these organizations have had good success in filling their needs for degreed (non-nuclear) scientists and engineers. The interviewed companies also expect the supply of degreed (non-nuclear) scientists and engineers to be large enough to meet their manpower requirements in 1970 and 1973.

None of the interviewed companies felt that their degreed (non-nuclear) scientists and engineers would particularly benefit from additonal coursework in nuclear science and engineering. It should also be noted that these organizations have never employed, nor are they planning to employ, nuclear degreed scientists and engineers. They do not believe the technical requirements of

their industry are such that they need the technical sophistication of a nuclear degreed individual.

Experience is the primary employment qualification for hiring technicians. Technicians employed in the industrial radiography industry work primarily in test and evaluation activities. Other company activities where technicians work are, installations, operations and maintenance, teaching and training, and technical assistance and consulting.

These companies have had very good success in attracting technicians during the past five years, and they do not expect any difficulty in the future. The companies do believe, however, that should a shortage occur, they will be able to train unskilled technicians through "in-house" educational programs.

The companies did indicate that their technicians would benefit from some coursework in radiation shielding, radioisotope techniques, radiological physics, and radiation safety.

The primary extrinsic factor used by these companies in forecasting their technical manpower requirements is the "general economic outlook." The most reliable intrinsic factors are "sales forecasts" and "historical employment data."

MISCELLANEOUS

BLS Segment Definition -- Reporting units engaged in nuclear activities which are not classifiable in any of the previous segments.

PRESENTATION OF STATISTICAL DATA

In 1968, the interviewed companies employed 54.7% of all engineers, 100.0% of all scientists, and 29.8% of all technicians working at companies reporting in the BLS's miscellaneous segment. Historical data for scientists, engineers, and technicians employed at companies that report in the miscellaneous segment of the BLS survey are given below (The miscellaneous segment is composed primarily of government-owned-establishments, and therefore, extrapolations from the sample companies could only be made to the data reported to the BLS by the privately owned organizations -- 12.7% of the 1968 totals reported by BLS are for privately owned companies):

Historical BLS Data (1963-1968)

Year	Scientists	Engineers	Technicians	Totals
1963	51	257	223	531
1964	39	219	191	449
1965	26	165	174	365
1966	24	158	183	365
1967	56	132	141	329
1968	3	115	88	206

Data provided by the sample companies and extrapolated by the ANS to the entire number of companies reporting in the miscellaneous segment (privately owned) for 1969, 1970, and 1973 are presented in Table 15. The overall growth of these companies, in terms of technical manpower requirements, between July 1969 and December 31, 1973 is 64.5%.

Percentage increases between July 1969 and December 31, 1973 for each of the listed occupational categories are:

Table 15

– MISCELLANEOUS INDUSTRIES –

CURRENT (1969) EMPLOYMENT OF SCIENTISTS, ENGINEERS AND TECHNICIANS BY OCCUPATIONAL CATEGORIES AND ANS PROJECTIONS OF TECHNICAL MANPOWER REQUIREMENTS FOR 1970 AND 1973.

(Data include only personnel employed by privately-owned companies active in the atomic energy field but which are unclassifiable in any of the previously defined segments of the private sector of the atomic energy field. Only personnel who spend at least 50% of their working time in atomic energy activities are included.)

OCCUPATIONAL CATEGORIES	CURRENT EMPLOYMENT	1970	INCREASE/ DECREASE	1973	INCREASE/ DECREASE
PHYSICAL SCIENTISTS	10	13	+3	18	+5
LIFE SCIENTISTS	3	4	+1	6	+2
ENGINEERS	89	107	+18	142	+35
MATHEMATICIANS	3	4	+1	6	+2
DRAFTSMEN	41	47	+6	59	+12
ELECTRICAL & ELECTRONICS TECHNICIANS	26	31	+5	45	+14
OTHER ENGINEERING TECHNICIANS	15	17	+2	22	+5
HEALTH PHYSICS TECHNICIANS & RADIATION MONITORS	6	9	+3	12	+3
LIFE SCIENCE TECHNICIANS	2	2	–	2	–
PHYSICAL SCIENCE TECHNICIANS	8	10	+2	16	+6
OTHER TECHNICIANS	8	12	+4	16	+4
NUCLEAR REACTOR OPERATORS	3	5	+2	8	+3
TOTALS	**214**	**261**	**+47**	**352**	**+91**

MISCELLANEOUS

Occupational Categories	% Increase Between July 1969 and December 31, 1973	Numerical Increase Between July 1969 and December 31, 1973
Nuclear Reactor Operators	166.7%	5
Other Technicians	100.0%	8
Physical Science Technicians	100.0%	8
Health Physics Technicians & Radiation Monitors	100.0%	6
Life Scientists	100.0%	3
Mathematicians	100.0%	3
Physical Scientists	80.0%	8
Electrical/Electronics Technicians	73.1%	19
Engineers	59.6%	53
Other Engineering Technicians	46.7%	7
Draftsmen	43.9%	18
TOTALS	64.5%	138

Consolidating the above occupational categories into three broad categories of scientists, engineers, and technicians, shows the following percentages of increase between July 1969 and December 31, 1973:

Occupational Categories	% Increase Between July 1969 and December 31, 1973	Numerical Increase Between July 1969 and December 31, 1973
Scientists (Includes Mathematicians)	87.5%	14
Technicians (Includes Draftsmen & Nuclear Reactor Operators	65.1%	71
Engineers	59.6%	53

Chart 16 represents the actual historical BLS technical manpower data (1963-1968) for all non-government-owned companies reporting in the BLS's miscellaneous

segment and ANS projections of the companies' requirements for technical personnel through 1973.

Currently there are only 5 nuclear engineers and 1 nuclear scientist employed by the privately owned companies active in this segment of the atomic energy field. These companies, however, expect to hire an additional nuclear scientist and 3 additional nuclear engineers to fill new positions between July 1969 and December 31, 1973.

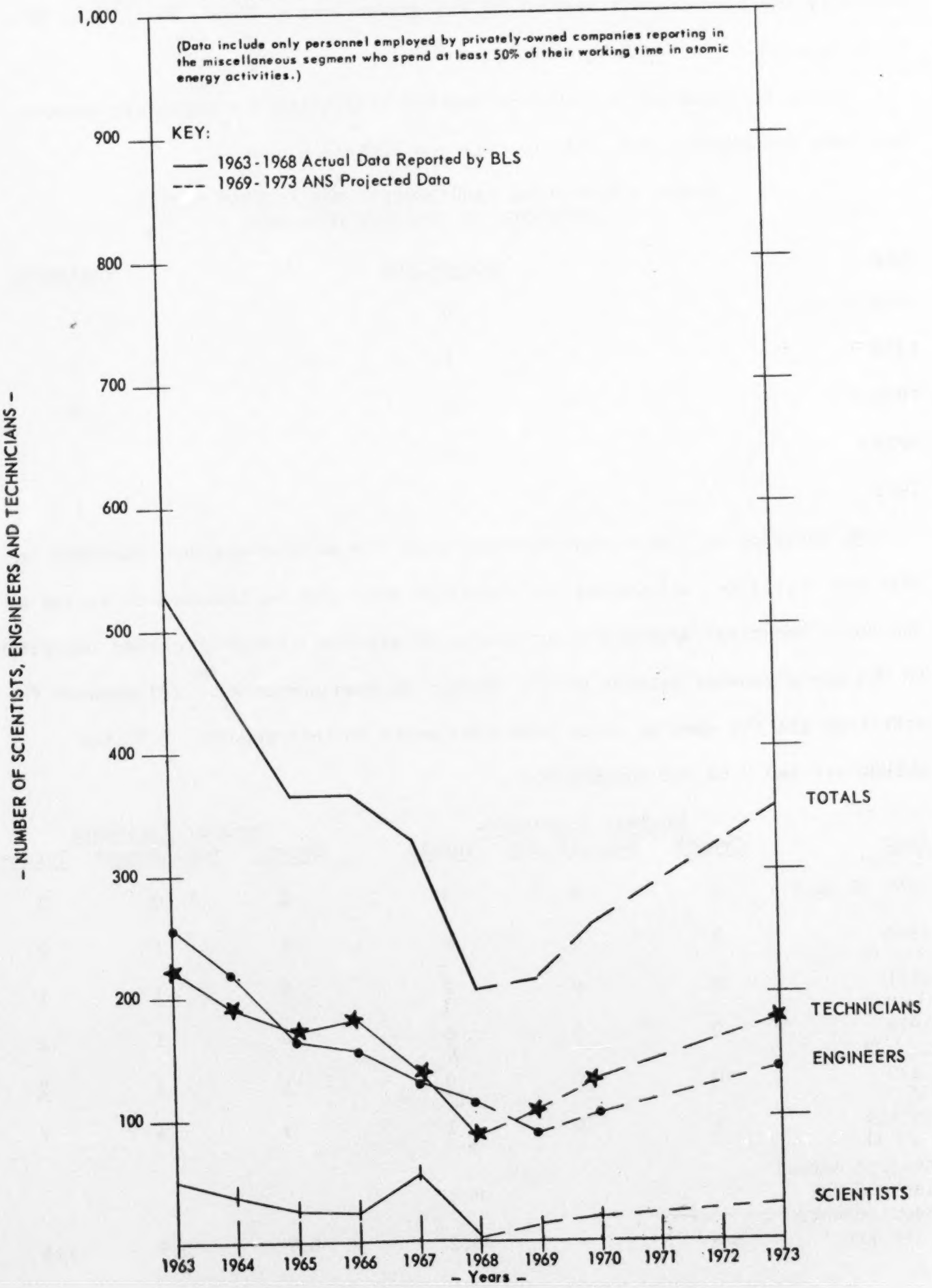
Percentages of currently employed scientists and engineers with a particular educational background to the total number of currently employed scientists and engineers are as follows:

Educational Backgrounds	% of Currently Employed Scientists and Engineers	Number of Currently Employed Scientists and Engineers
Mechanical Engineering	28.4%	29
Electrical/Electronics Engineering	17.6%	18
Chemical Engineering	13.7%	14
Physics	7.8%	8
Metallurgical Engineering	6.9%	7
Other Engineering Disciplines	6.9%	7
Civil Engineering	5.9%	6
Chemistry	4.9%	5
Nuclear or Reactor Engineering	4.9%	5
Metallurgy	2.0%	2
Nuclear Physics	1.0%	1
TOTALS	100.0%	102

Of the currently employed nuclear degreed scientists and engineers, 66.7% have MS's and 33.3% have PhD's. Of the other degreed (non-nuclear) personnel

Chart 16

EMPLOYMENT OF SCIENTISTS, ENGINEERS AND TECHNICIANS BY COMPANIES REPORTING IN THE MISCELLANEOUS SEGMENT OF THE PRIVATE SECTOR OF THE ATOMIC ENERGY FIELD FOR EACH YEAR EXTENDING FROM 1963 THROUGH 1968 (AS REPORTED BY THE BUREAU OF LABOR STATISTICS) AND ANS PROJECTIONS OF THE TECHNICAL MANPOWER REQUIREMENTS FOR 1969, 1970 AND 1973.



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currently employed in this segment of the atomic energy field, 59.4% have BS's, 33.3% have MS's, and 7.3% have PhD's.

Annual requirements for nuclear degreed scientists and engineers between July 1969 and December 31, 1973 to fill new positions are:

ANNUAL INCREMENTAL REQUIREMENTS FOR NUCLEAR DEGREED PERSONNEL TO FILL NEW POSITIONS

Year	Scientists	Engineers
1969 (6 mo.)	0	1
1970	1	1
1971	0	0
1972	0	0
1973	0	1

In addition to these organizations' need for nuclear degreed personnel to fill new positions, allowances for attrition must also be included to arrive at the total technical manpower requirements of privately owned companies reporting in the miscellaneous segment of the nuclear degreed personnel. (Allowances for attrition are the same as those used previously in this report: 8.4% for scientists and 7.6% for engineers.)

	Nuclear Scientists			Nuclear Engineers		
Year	Growth	Replacement	Totals	Growth	Replacement	Totals
1969 (6 mo.)	0	0	0	1	0	1
1970	1	0	1	1	1	2
1971	0	0	0	0	1	1
1972	0	0	0	0	1	1
1973	0	0	0	1	1	2
TOTALS	1	0	1	3	4	7
Average Annual Incremental Requirements (4½ yrs.)	0.2	-	0.2	0.7	0.9	1.6

Between July 1969 and December 31, 1973 a total of 8 nuclear degreed scientists and engineers will be needed by all privately owned organizations reporting in the miscellaneous segment of the BLS survey. This total requirement averages out to slightly less than 2 nuclear degreed scientists and engineers each year to fill new and replacement positions within these organizations.

SUMMATION OF IN-DEPTH INTERVIEWS

Atomic energy activities in which the interviewed companies are involved include; space systems research and development, manufacturing of special nuclear products (i.e. radiation shielding containers), and consulting, and general service organizations. Rather than presenting the responses for each of these organizations, thus avoiding undue repetitiveness, only the highlights will be presented. These highlights include only information which represents an exception to the responses of all of the interviewed companies or an interesting opinion.

1) Special nuclear products manufacturing and service organizations have increased, although modestly, their requirements for nuclear degreed scientists and engineers due to new product developments and service requirements of the atomic energy field.

2) The service organizations believe, however, that nuclear degreed scientists and engineers are generally too specialized in reactor technology, and what they need are more scientists and engineers with a knowledge of isotope applications.

3) Consulting organizations were very critical of all specialists, as they prefer the scientist or engineer who has had a broad educational background. In other words, they prefer the generalist!

4) The space systems research and development organizations indicated that their nuclear degreed personnel have excellent theoretical backgrounds, but there is a a feeling that these same individuals lack practical exposure to design problems.

MISCELLANEOUS

5) Only the consulting organizations would be affected by a 10% reduction in government funds to their company. Such a reduction would result in about an 8% decrease in their manpower estimates for 1970 and 1973. The space systems organizations, although historically dependent upon government funds, are currently in the process of broadening their base of operations so that reductions in government funds would not affect their personnel levels. These organizations are building up their nuclear capability in anticipation of nuclear space appli= cations in the civilian market and do not want to cut back on their staff under any circumstances.

6) The consulting organizations believe their area of activity in the atomic energy field will level off between 1973 and 1975 and, in order for them to continue their growth, they are planning to become involved in other nuclear related activities.

7) Consulting firms do not believe their degreed employee would benefit from additional coursework in nuclear science and engineering. Their general approach to continuing education, as it affects the company, is to provide special technological seminars on various subjects as the need arises.

8) The consulting organizations would like the universities to stress the economic and management considerations of the electric utility industry for the training of nuclear engineers.

9) The space systems organizations would like to see nuclear degreed people have more coursework in systems engineering and basic business economics as they apply to the nuclear field.

10) Manufacturers of special nuclear products would like all engineers to have more coursework or experience in teaching techniques, applications of radio- isotopes and radiation physics.

TECHNICAL MANPOWER REQUIREMENTS OF THE ELECTRIC POWER UTILITIES

SUMMARY OF FINDINGS

Following are some of the major findings of the utility survey:

1) When a utility builds additional nuclear power plants, on-site personnel increase dramatically while central office or off-site personnel remain relatively constant;

2) A significant increase, although numerically small, in the number of scientists that will be hired between July 1969 and December 31, 1973;

3) By 1973 there will be 1 senior reactor operator for every 2.3 reactor operators;

4) An increased emphasis will be placed on the hiring of BS nuclear engineers;

5) An average of 77.6 technical personnel per nuclear power plant;

6) Between 1969 and 1973; 52 nuclear scientists and 361 nuclear engineers will be needed by the electric utility industry;

7) Utilities that do not now have nuclear power plants are taking a "wait-and-see" attitude on the performance, economics and social considerations of nuclear plants now being built or in operation;

8) The utilities are experiencing difficulty in hiring degreed technical level personnel, especially mechanical engineers;

9) 60% of the interviewed companies have been successful in hiring nuclear scientists and engineers;

10) The utilities have increased their need for nuclear degreed individuals because of:

    a. new nuclear power plant construction

    b. increasing requirements of AEC regulatory agencies

c. increased awareness of the benefits the nuclear engineer brings to the utility; and,

11) The electric utility industry must create a better image of itself if it wants to attract quality people.

NUCLEAR TRAINED MANPOWER NEEDS IN ELECTRIC POWER INDUSTRY

This study was conducted by Dr. A. David Rossin and Keith L. Voigt during the month of February 1969. The study, which utilized the direct-mail questionnaire technique, was cosponsored by the ANS Power Division and the Reactor Operations Division. Information was received from 35 U.S. utilities (46 were contacted). The data represents only those employees who had or will be required to have some nuclear training. Also, all companies contacted had or were planning to have nuclear power plants in operation by 1976.

Data obtained from the completed questionnaires were extrapolated to the entire national requirements based on published information concerning the power ratings and time schedules for the unreported plants.

The questionnaire included a detailed breakdown of occupational categories. On-site personnel were subdivided into three categories:

1. General and Operations
2. Maintenance (direct)
3. Technical Services

Each of these categories includes a number of specific functions; a total of 27 on-site functions in all. Off-site or central office personnel were subdivided into six categories:

1. Design and Safety Analysis
2. Research and Development
3. Construction
4. Operations and Fuel Cycle Management

5. Periodic Maintenance (rotating)

6. Administration and Other

These categories in turn, separate into 51 functions.

Obviously, such detailed categories and functions cannot be equally applicable to the many different organizations and structures of America's independent electric generating companies. However, all responding companies managed to provide meaningful answers that could be analyzed along with other returns.

Since the publication of the Rossin-Voigt study, a number of utilities have announced plans to build nuclear power plants. On the other hand, one (1) of the nuclear plants included in the Rossin-Voigt sample has since cancelled its plans to build a nuclear power plant. The data presented in this report have been updated to include these changes.

PRESENTATION OF STATISTICAL DATA

Whereas the Rossin-Voigt study extrapolated the data obtained from the sample companies to 89 projected nuclear power plants by 1976, the data in this report were extrapolated to 96 plants projected through 1977.

A comparison of the projected megawatts$_e$ of the 96 nuclear plants and the megawatts$_e$ of the 41 nuclear plants which comprise the sample is presented in Table 16. The megawatts$_e$ of these sample plants represent 42.1% of the total projected megawatts$_e$ for all 96 nuclear power plants planned for operation by 1977. Chart 17 shows the projected accumulated megawatts$_e$ of all nuclear power plants planned for operation by 1977 and the accumulated megawatts$_e$ of the nuclear power plants included in the survey sample.

For 1969, 1970, and 1973, the total number of personnel required, by company activity, by the electric utilities that have or are planning to have nuclear power plants operating by 1977 is presented in Tables 17, 18, and 19 respectively.

FLECTRIC POWER UTILITIES

Percentage increases between July 1969 and December 31, 1973 for the total number of on-site and off-site personnel are:

Location of Personnel	% Increase Between July 1969 and December 31, 1973	Numerical Increase Between July 1969 and December 31, 1973
On-Site	287.8%	3,629
Off-Site	84.7%	1,176

Off-site personnel represent 52.4% (1,388) of the total personnel currently employed at electric utilities, but by 1973 off-site personnel will represent only 34.4% (2,564) of all employees. Although off-site personnel will increase by 84.7% between July 1969 and December 31, 1973, on-site personnel will increase at a much faster rate (287.8%). These data seem to show that as additional nuclear power plants are built within a single utility system, the central office (off-site) personnel are spread over more plants. Obviously, this distribution of manpower over a number of plants does not occur to the same extent for on-site personnel. In addition, the majority of degreed personnel work at the central office rather than being assigned to work at a plant.

	(% of Total Manpower Reported)		
	1969	1970	1973
Location of Personnel	Degree-Non Degree	Degree-Non Degree	Degree-Non Degree
On-Site	19.1% -- 80.9%	14.7% -- 85.3%	13.0% -- 87.0%
Off-Site	76.9% -- 23.1%	74.7% -- 25.3%	76.4% -- 23.6%

The proportion of college degree holders among the central office staff is even more pronounced if the periodic maintenance function is excluded. In fact, since central periodic maintenance organizations have only begun to be set up, almost all (90.8%) of the central office staff will hold college degrees. Similarly, if technical services staff were excluded from the on-site classification, very few on-site people would have college degrees (6.2%).

The consolidation of both on-site and off-site personnel into broad

Table 16

– ELECTRIC POWER UTILITIES –

COMPARISON OF PLANNED NUCLEAR POWER PLANT MEGAWATTS$_e$ BY THE YEAR IN WHICH THEY WILL BEGIN OPERATION AND THE MEGAWATTS$_e$ OF THE ANS SURVEY'S SAMPLED NUCLEAR POWER PLANTS BY THE YEAR IN WHICH THEY WILL BEGIN OPERATION.

	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
NUMBER OF NUCLEAR GENERATING PLANTS BY YEAR IN WHICH THEY WILL BEGIN OPERATION AND THEIR NET MEGAWATT$_e$ CAPACITY*	401** 575 265 200 430 790 175	515 500 420	873 652 715 715 715 700 545 330 497 700	625 831 1,065 514 715 457 497 886 652 1,064 780 780	965 790 1,050 1,050 778 1,054 530 527 850 886 652 858 1,064 1,065 1,060	847 810 821 838 1,065 1,050 1,050 492 1,126 1,060 545 800 886 770 786 1,124 800	828 818 515 530 872 800 821 1,124 845 1,060 1,118	1,115 819 1,052 1,065 1,100 840 829 462	821 821 1,100 1,100	1,052 1,065 1,100
NUMBER OF NUCLEAR GENERATING UNITS (NUMBER OF SAMPLE SURVEY UNITS)	12 (5)	4 (1)	10 (6)	12 (4)	15 (9)	17 (7)	11 (4)	8 (4)	4 (–)	3 (1)
NUMBER of NUCLEAR PLANTS (Accumulative) (NUMBER of SAMPLE NUCLEAR PLANTS – Accumulative)	12 (5)	16 (6)	26 (12)	38 (16)	53 (25)	70 (32)	81 (36)	89 (40)	93 (40)	96 (41)
NUCLEAR PLANT MEGAWATTS$_e$ (TOTAL ANNUAL MEGAWATTS$_e$)	2,836	1,435	6,442	8,866	13,179	14,870	9,331	7,282	3,842	3,217
NUCLEAR PLANT MEGAWATTS$_e$ (Accumulative Megawatts$_e$)	2,836	4,271	10,713	19,579	32,758	47,628	56,959	64,241	68,083	71,300
SAMPLE SURVEY NUCLEAR PLANT MEGAWATTS$_e$	630	420.	4,263	3,318	7,296	6,151	2,735	4,099	---	1,065
SAMPLE SURVEY NUCLEAR PLANT MEGAWATTS$_e$ (Accumulative Megawatts$_e$)	630	1,050	5,313	8,631	15,927	22,078	24,813	28,912	28,912	29,977
PERCENT SAMPLE SURVEY PLANT MEGAWATTS$_e$ TO TOTAL PROJECTED MEGAWATTS$_e$	22.2	24.6	49.6	44.1	48.6	46.4	43.6	45.0	42.5	42.1

* Source: U.S. Atomic Energy Commission

** Represents 7 Units under 175 Mwe.

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Chart 17

COMPARISON OF THE TOTAL ACCUMULATED MEGAWATTS$_e$ OF THE CURRENT AND PLANNED FOR NUCLEAR POWER PLANTS BY YEAR OF OPERATION THROUGH 1977 AND THE ACCUMULATED MEGAWATTS$_e$ OF THE ANS SURVEY'S SAMPLED NUCLEAR POWER PLANTS BY THE YEAR IN WHICH THEY WILL BEGIN OPERATION.

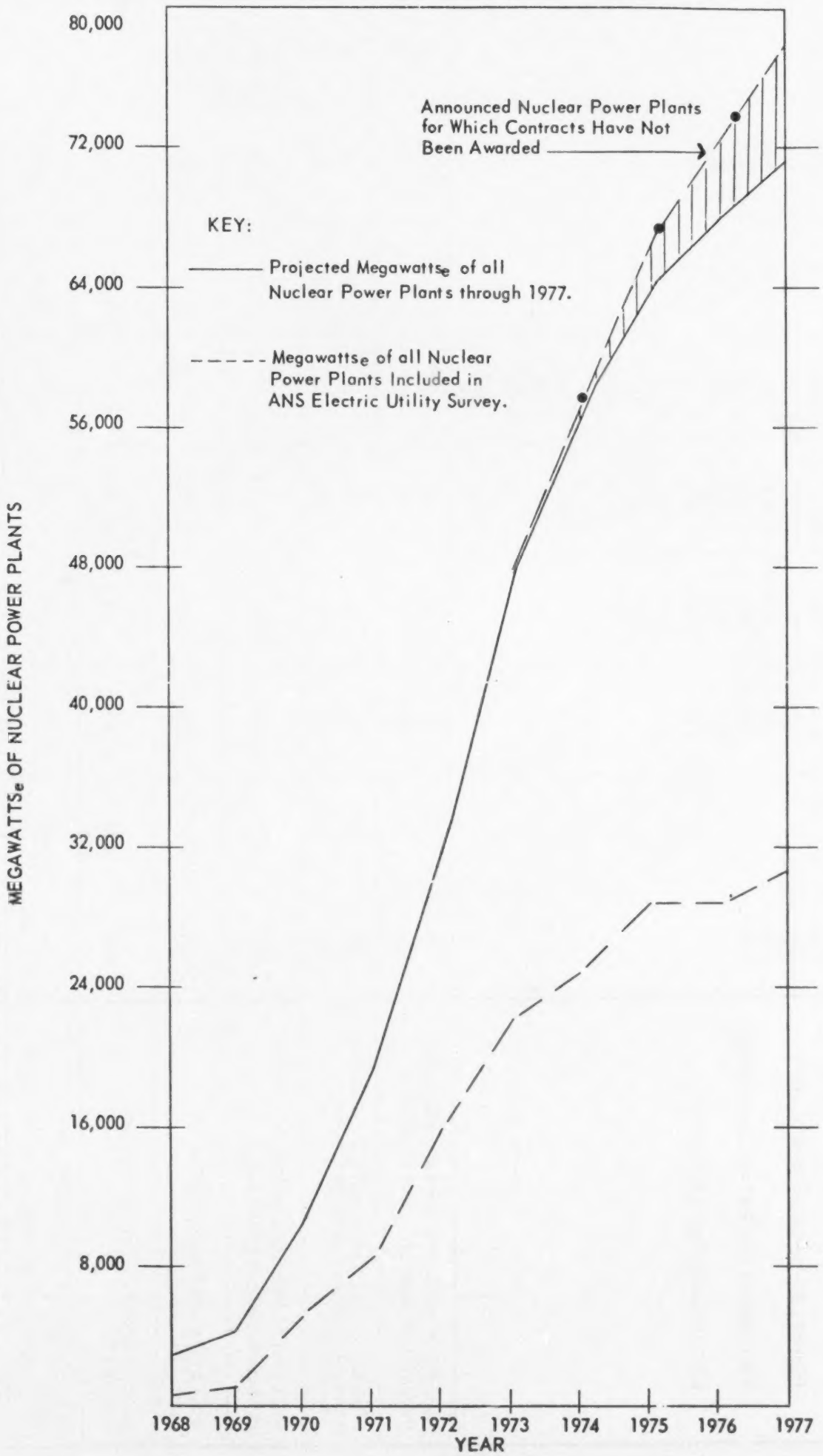

Table 17

– ELECTRIC POWER UTILITIES –

CURRENT (1969) EMPLOYMENT OF PERSONNEL BY COMPANY ACTIVITY, DEGREE VERSUS NON-DEGREE AND LEVEL OF DEGREE.

(Data include only personnel employed by electric power utilities that have or are planning to have a nuclear power plant(s) in operation by 1977. Only personnel who have had "some" nuclear training are included.)

	FUNCTIONS	TOTALS	NON-DEGREE	DEGREE	LEVEL OF DEGREE		
					PhD	MS	BS
ON-SITE	GENERAL & OPERATIONS	632	539	93	---	8	85
ON-SITE	MAINTENANCE	225	215	10	---	---	10
ON-SITE	TECHNICAL SERVICES	404	266	138	2	20	116
	TOTAL – ON-SITE	1,261	1,020	241	2	28	211
OFF-SITE	DESIGN & SAFETY ANALYSIS	633	20	613	4	102	507
OFF-SITE	RESEARCH & DEVELOPMENT	39	4	35	---	11	24
OFF-SITE	CONSTRUCTION	129	20	109	---	7	102
OFF-SITE	OPERATIONS & FUEL CYCLE MANAGEMENT	164	21	143	4	34	105
OFF-SITE	PERIODIC MAINTENANCE	276	253	23	---	2	21
OFF-SITE	ADMINISTRATION	147	2	145	---	22	123
	TOTAL – OFF-SITE	1,388	320	1,068	8	178	882
	GRAND TOTALS	2,649	1,340	1,309	10	206	1,093

Table 18
– ELECTRIC POWER UTILITIES –

ESTIMATED 1970 EMPLOYMENT OF PERSONNEL BY COMPANY ACTIVITY, DEGREE VERSUS NON-DEGREE AND LEVEL OF DEGREE.
(Data include only personnel planned for employment by electric power utilities in 1970 that have or are planning to have a nuclear power plant(s) in operation by 1977. Only personnel who have had or will be required to have "some" nuclear training are included.)

	FUNCTIONS	TOTALS	NON-DEGREE	DEGREE	LEVEL OF DEGREE		
					PhD	MS	BS
ON-SITE	GENERAL & OPERATIONS	1,461	1,312	149	---	9	140
	MAINTENANCE	833	812	21	---	---	21
	TECHNICAL SERVICES	846	554	292	2	45	245
TOTAL – ON-SITE		**3,140**	**2,678**	**462**	**2**	**54**	**406**
OFF-SITE	DESIGN & SAFETY ANALYSIS	862	36	826	5	146	675
	RESEARCH & DEVELOPMENT	48	5	43	---	12	31
	CONSTRUCTION	199	37	162	---	5	157
	OPERATIONS & FUEL CYCLE MANAGEMENT	319	59	260	7	61	192
	PERIODIC MAINTENANCE	392	362	30	---	5	25
	ADMINISTRATION	171	4	167	---	27	140
TOTAL – OFF-SITE		**1,991**	**503**	**1,488**	**12**	**256**	**1,220**
GRAND TOTALS		**5,131**	**3,181**	**1,950**	**14**	**310**	**1,626**

Table 19

– ELECTRIC POWER UTILITIES –

ESTIMATED 1973 EMPLOYMENT OF PERSONNEL BY COMPANY ACTIVITY, DEGREE VERSUS NON-DEGREE AND LEVEL OF DEGREE.

(Data include only personnel planned for employment by electric power utilities in 1973 that have or are planning to have a nuclear power plant (s) in operation by 1977. Only personnel who have had or will be required to have "some" nuclear training are included.)

	FUNCTIONS	TOTALS	NON-DEGREE	DEGREE	LEVEL OF DEGREE		
					PhD	MS	BS
ON-SITE	GENERAL & OPERATIONS	2,279	2,089	190	---	9	181
ON-SITE	MAINTENANCE	1,369	1,332	37	---	---	37
ON-SITE	TECHNICAL SERVICES	1,242	833	409	3	52	354
	TOTAL – ON-SITE	4,890	4,254	636	3	61	572
OFF-SITE	DESIGN & SAFETY ANALYSIS	1,100	37	1,063	6	184	873
OFF-SITE	RESEARCH & DEVELOPMENT	57	6	51	---	16	35
OFF-SITE	CONSTRUCTION	254	50	204	---	6	198
OFF-SITE	OPERATIONS & FUEL CYCLE MANAGEMENT	487	86	401	6	89	306
OFF-SITE	PERIODIC MAINTENANCE	456	413	43	---	8	35
OFF-SITE	ADMINISTRATION	210	14	196	---	33	163
	TOTAL – OFF-SITE	2,564	606	1,958	12	336	1,610
	GRAND TOTALS	7,454	4,860	2,594	15	397	2,182

classifications of scientists, engineers, technicians and others is presented in Table 20. The percent increases, for each classification, between July 1969 and December 31, 1973 are:

Class of Employees	% Increase Between July 1969 and December 31, 1973	Numerical Increase Between July 1969 and December 31, 1973
Scientists	220.7%	64
Engineers	95.4%	1,221
Technicians	228.2%	938
Others	277.9%	2,582
TOTALS	181.4%	4,805

Although the overall personnel levels at these utilities will grow at a rate of 181.4% between July 1969 and December 31, 1973, engineering manpower (numerically the largest group in 1969) will grow at a rate (95.4%) less than all other groups during this time period. It is also interesting to note that requirements for scientists will increase by 220.7% (although this group is numerically the smallest). Perhaps the utilities are turning to the scientists to help them develop programs to overcome the objections now being raised with regard to ecology.

Table 21 presents data concerning the total number of senior and reactor operators currently employed and projections of the utilities' requirements for these types for 1970 and 1973. The number of senior and reactor operators will grow at an overall rate of 374.6% between July 1969 and December 31, 1973. By the end of 1973, reactor operators will represent 69.6% of the total number of senior and reactor operators. The ratio of reactor operators to senior reactor operators (supervisors) is currently 2.6/1 and will be 2.3/1 in 1973.

The total number of currently employed nuclear degreed scientists and engineers and projections of the utilities' requirements for these types in

Table 20

– ELECTRIC POWER UTILITIES –

CURRENT (1969) EMPLOYMENT OF SCIENTISTS, ENGINEERS, TECHNICIANS AND "OTHERS" AND ANS PROJECTIONS OF MANPOWER REQUIREMENTS FOR 1970 AND 1973.

(Data include only personnel currently (1969) employed and planned for employment in 1970 and 1973 by electric power utilities that have or are planning to have a nuclear power plant(s) in operation by 1977. Only personnel who have had or will be required to have "some" nuclear training are included.)

OCCUPATIONAL CATEGORIES	CURRENT EMPLOYMENT	1970	INCREASE/ DECREASE	1973	INCREASE/ DECREASE
SCIENTISTS (Includes Mathematicians)	29	60	+31	93	+33
ENGINEERS	1,280	1,890	+610	2,501	+611
TECHNICIANS	411	909	+498	1349	+440
OTHERS	929	2,272	+1,343	3,511	+1,239
TOTALS	2,649	5,131	+2,482	7,454	+2,323

Table 21

– ELECTRIC POWER UTILITIES –

CURRENT (1969) EMPLOYMENT OF SENIOR REACTOR OPERATORS AND REACTOR OPERATORS AND ANS PROJECTIONS OF MANPOWER REQUIREMENTS FOR THESE TYPES FOR 1970 AND 1973 – These data are included in the TECHNICIANS and OTHERS categories of Table 20.

(Data include only personnel currently (1969) employed and planned for employment in 1970 and 1973 by electric power utilities that have or are planning to have a nuclear power plant(s) in operation by 1977. Only personnel who have had or will be required to have "some" nuclear training are included.)

OCCUPATIONAL CATEGORIES	CURRENT EMPLOYMENT	1970	INCREASE/ DECREASE	1973	INCREASE/ DECREASE
SENIOR REACTOR OPERATORS	50	157	+107	261	+104
REACTOR OPERATORS	131	377	+246	598	+221
TOTALS	181	534	+353	859	+325

Table 22

– ELECTRIC POWER UTILITIES –

CURRENT (1969) EMPLOYMENT OF NUCLEAR-DEGREE SCIENTISTS AND ENGINEERS AND ANS PROJECTIONS OF MANPOWER REQUIREMENTS FOR THESE TYPES FOR 1970 AND 1973 – These data are included in the SCIENTISTS and ENGINEERS categories of Table 20.

(Data include only personnel currently (1969) employed and planned for employment in 1970 and 1973 by electric power utilities that have or are planning to have a nuclear power plant(s) in operation by 1977. Only personnel who have had or will be required to have "some" nuclear training are included.)

OCCUPATIONAL CATEGORIES	CURRENT EMPLOYMENT	1970	INCREASE/ DECREASE	1973	INCREASE/ DECREASE
SCIENTISTS	12	35	+23	50	+15
ENGINEERS	167	295	+128	409	+114
TOTALS	179	330	+151	459	+129

1970 and 1973 are presented in Table 22. Employment of nuclear degreed personnel will grow at a rate of 156.4% (280) between July 1969 and December 31, 1973. By the end of 1973, nuclear engineers will outnumber nuclear scientists by about 8 to 1.

Table 23 shows the comparison of the number of degreed employees for 1969, 1970, and 1973, by level of degree, for both nuclear degreed and degreed (non-nuclear) personnel. For nuclear degreed personnel, there is an increased emphasis for BS level individuals (1969 - 44.9%; 1970 - 48.4%; and, 1973 - 53.9%). Corresponding to this emphasis on BS level nuclear degreed personnel is a slight de-emphasis on MS level nuclear degreed individuals. This de-emphasis also occurs for PhD level nuclear degreed individuals.

The average number of personnel for each nuclear plant (96 plants) was calculated at 77.6 (based on the 1973 employment statistics). Approximately 50.9 employees will work at the plant site while the remaining 26.7 employees will be centered at the utilities' central offices. Of the almost 78 employees per plant, 51 will have no degree and 27 will have degrees. As was previously stated, the vast majority (90%) of the degreed staff will work at the central office while nearly 94% of the non-degreed staff will work at the plant site.

Annual incremental requirements for nuclear degreed personnel to fill new positions will be:

Year	Annual Incremental Requirements for Nuclear Degreed Personnel to Fill New Positions	
	Scientists	Engineers
1969 (6 mo.)	7	43
1970	16	85
1971	5	38
1972	5	38
1973	5	38

Table 23

– ELECTRIC POWER UTILITIES –

BREAKDOWN OF NUCLEAR-DEGREE AND DEGREE (NON-NUCLEAR) PERSONNEL CURRENTLY (1969) EMPLOYED AND PLANNED FOR EMPLOYMENT IN 1970 AND 1973, BY LEVEL OF DEGREE – Data do not include degree Mathematicians.

(Data include only personnel currently (1969) employed and planned for employment in 1970 and 1973 by electric power utilities that have or are planning to have a nuclear power plant(s) in operation by 1977. Only personnel who have had or will be required to have "some" nuclear training are included.)

LEVEL OF DEGREE	TOTAL NUCLEAR DEGREED = 179	% OF TOTAL	TOTAL NON-NUCLEAR DEGREED = 1,130	% OF TOTAL
BS	80	44.9%	1,013	89.6%
MS	91	50.6%	115	10.2%
PhD	8	4.5%	2	0.2%

– 1970 –

LEVEL OF DEGREE	TOTAL NUCLEAR DEGREED = 330	% OF TOTAL	TOTAL NON-NUCLEAR DEGREED = 1,620	% OF TOTAL
BS	160	48.4%	1,466	90.5%
MS	160	48.4%	150	9.3%
PhD	10	3.2%	4	0.2%

– 1973 –

LEVEL OF DEGREE	TOTAL NUCLEAR DEGREED = 458	% OF TOTAL	TOTAL NON-NUCLEAR DEGREED = 2,136	% OF TOTAL
BS	247	53.9%	1,935	90.6%
MS	198	43.2%	199	9.3%
PhD	13	2.9%	2	0.1%

ELECTRIC POWER UTILITIES

In addition to the electric utilities' need for nuclear degreed scientists and engineers to fill new positions, allowances for attrition must also be included to arrive at the total technical manpower requirements of the electric utilities for nuclear degreed personnel. (Allowances for attrition are the same as those previously used in this report: 8.4% for scientists and 7.6% for engineers.)

	Nuclear Scientists			Nuclear Engineers		
Year	Growth	Replacements	Total	Growth	Replacements	Total
1969-(6 mo.)	7	1	8	43	13	56
1970	16	3	19	85	22	107
1971	5	3	8	38	25	63
1972	5	3	8	38	28	66
1973	5	4	9	38	31	69
TOTALS	38	14	52	242	119	361
Average Annual Incremental Requirements (4½ years)	8.4	3.1	11.5	53.8	26.4	80.2

Between July 1969 and December 31, 1973, the total requirements of the electric utilities for nuclear degreed scientists and engineers are 52 and 361 respectively. For every nuclear scientist hired by the utilities, about 7 nuclear engineers will be hired.

SUMMATION OF IN-DEPTH INTERVIEWS

In addition to updating the statistical data provided by the Rossin-Voigt study, the present study incorporated in-depth interviews with a representative sample of U.S. utilities. These utilities will have a total of 29 operating nuclear power plants by 1977 at a combined total megawattage$_e$ of 21,862 (30.7% of the total megawatts$_e$ for all U.S. nuclear power plants planned for operation by 1977). The average plant size of the interviewed utilities is 754 megawatts$_e$.

A number of factors are utilized by the electric utilities to arrive at estimates of their technical manpower requirements. However, most of the utilities placed emphasis on what the "state of the art" of the electric utility industry will be in the future. For example, what are the possible new modes of electric power generation? What are the economic and esthetic considerations? With regard to the evaluation of the "state of the art," they feel that the current slowdown in orders for nuclear power plants reflects the utilities' "wait-and-see" attitude on the performance, economics, and social considerations of nuclear power plants now being built or in operation.

When hiring a scientist or engineer in general, the majority of the interviewed companies indicated that the primary employment qualification is a combination of the extent of education and experience. More specifically, when the utilities hire technical personnel to fill their short-range manpower requirements, they hire exactly what they need at the present time. In this instance, emphasis is placed on the candidate's experience in the electric power industry or a closely related industry as he will be required to immediately assume a responsible position without a significant amount of supervision or training. However, when the utilities hire personnel to fill their long-range manpower requirements, the companies tend to hire a man for his potential usefulness. As a result, level of degree, age, etc. become important employment factors.

Over 50% of the interviewed companies have experienced some difficulty in hiring degreed (non-nuclear) scientists and engineers during the past five years. This difficulty is especially acute with regard to mechanical engineers and engineers capable of assuming quality control responsibilities. All companies feel that the present manpower market is extremely tight for engineering types and they foresee no let-up in the near future, especially in

view of decreasing engineering enrollments.

All interviewed companies believe their degreed (non-nuclear) technical staff can adequately adapt to and function in nuclear power plant technology because nearly 90% of nuclear power plant operations consist of conventional components which do not require the technical sophistication of nuclear engineers. Although the utilities indicated they would like their degreed individuals to have some nuclear training, they prefer to have their engineers take short or semester courses in nuclear technology after they have worked at the utility for a period of time. Some of the nuclear courses they would like their degreed (non-nuclear) engineers to be exposed to are:

1. Radiation shielding
2. Reactor materials
3. Radiochemistry
4. Health physics
5. Fuel cycle management
6. Radiation safety
7. Radioactive waste disposal

Furthermore, the electric utilities would like to see the universities incorporate some of these nuclear courses in their engineering curriculum, but not at the expense of eliminating or de-emphasizing the basic engineering courses. In other words, the utilities would encourage the educational institutions to keep their engineering programs "up-to-date" with some coverage of the new technological advances while maintaining their emphasis on the classical engineering concepts.

The utilities also believe it unfortunate that there are only a few graduate courses in engineering which are specifically geared to the power industry. This is especially true in electrical engineering where the emphasis is placed on

electronics rather than rotating machinery. With regard to chemical engineering, they would like the universities to include environmental considerations in their curriculums.

The primary employment qualification the utilities consider when hiring a nuclear degreed scientist or engineer is the extent of the candidate's previous nuclear training or experience. They hire these specialists not only to broaden their nuclear expertise in view of the increasing complexity of AEC regulatory requirements but also to use the nuclear engineer as a training vehicle for the rest of the technical staff.

Sixty percent of the interviewed companies indicated, at the time of the interview, that they have been successful in filling their needs for nuclear degreed personnel. Their success was attributed to the utilities' decision to pay higher salaries for nuclear degreed individuals than they would normally pay for equivalent degreed (non-nuclear) personnel. Furthermore, because these utilities have or are in the process of building a nuclear power plant, it seems they are able to attract nuclear degreed individuals more readily than utilities which are only in the planning stages. It was also obvious that the utilities which are experiencing some difficulty in filling their needs for nuclear engineers are still operating under the belief that "there are a lot of people who will accept a salary of $25,000 but have only $10,000 worth of experience."

Another important factor which has contributed to the success of these utilities in hiring nuclear degreed individuals is that these companies have established, through their professional recruitors, good rapport with the nuclear science and engineering faculty. It was also interesting to note that each utility has its own 4 or 5 "pet" schools to which they go when they need to hire a nuclear engineer. Although these "pet" schools are normally in the same geographical area as the utility, there are 3 or 4 schools which most utilities

contact for nuclear engineering students outside their geographical location.

The interviewed utilities have increased their need for nuclear degreed personnel during the past five years primarily because of: 1) new nuclear power plant construction; 2) the complexity of AEC licensing requirements; and, 3) an increased awareness of the technical benefits derived from nuclear engineers. The utilities are becoming increasingly aware of the fact that nuclear degreed individuals are generally able to add significantly to the utilities expertise and, as a result, they believe that the nuclear engineer is coming into his own!

In evaluating the applicability of nuclear engineers to the technical requirements of the utility industry, the companies generally feel that although the nuclear engineer is technically capable, the utilities are still required to train these individuals in the basics of operating an electric utility. There was some criticism of the nuclear engineer as generally being too theoretically oriented and not grounded in the fundamental aspects of applied engineering. In this regard, the utilities favor the hiring of nuclear engineers from schools which have a training reactor.

Some of the suggestions offered in response to an evaluation of the training received by nuclear engineers were: 1) nuclear engineers should receive more course work relating to quality control and quality assurance, and 2) at the bachelor's level the nuclear engineer seems to be weak in fluids, heat transfer, and strength of materials technologies.

When hiring technicians, the utilities generally look at the candidate's potential usefulness. They are primarily interested in the high school graduate who has had some science coursework.

Approximately two-thirds of these companies have experienced various degrees of difficulty in attracting qualified technician-level personnel. To overcome

this shortage, most of the utilities have incorporated "in-house" training programs.

One of the major problems facing the utilities with regard to the hiring of technicians is the wage and hourly union agreements which have limited their ability to hire experienced and skilled technicians. This has also contributed to their development of "in-house" training programs for technicians.

Some of the nuclear related courses the utilities deem important for their technicians are:

1. Waste disposal
2. Reactor instrumentation
3. Radiochemistry
4. Health physics

None of the interviewed companies were unduly concerned with filling their needs for nuclear reactor operators because they place the primary responsibility for the training of these individuals with their reactor vendor.

Perhaps the most interesting statement made by one of the interviewed companies regarding the difficulty they are having in hiring degreed people was that the utilities must help to create a better image of their industry at the universities by making the faculty and students more aware of the problems facing the utilities. It is believed that this would stimulate more students to pursue a career with the electric power utilities.

TECHNICAL MANPOWER REQUIREMENTS OF THE EDUCATIONAL INSTITUTIONS

SUMMARY OF FINDINGS

The study involved two separate surveys. The "first" survey was conducted in December, 1967 and included completed questionnaires from 183 schools. Because there was a long delay between the completion of the university survey and the surveys concerned with the manpower requirements of private industry and electric utilities, another study was made with a sample of 25 universities that had participated in the "first" survey. The purpose of the "second" survey was to update the data provided by the 183 schools in the "first" survey.

Some of the significant results of the comparison of the data reported by the 18 sample schools in the "first" survey and what they reported in the "second" survey are:

1. The "second" survey showed a 5.7% increase in the currently employed staff, no change in staff requirements for 1970 and a 5.0% increase in the technical manpower requirements for 1973.
2. For currently employed part-time R & D personnel, the "second" report showed an increase of 34.2% over what the sample schools reported in the "first" survey. The "second" survey also showed a 15.3% and 34.6% increase in requirements for part-time R & D personnel in 1970 and 1973 respectively.
3. Data reported in the "second" survey, as compared to what was reported in the "first" survey by the 18 sample schools, indicated a decrease in full-time nuclear facilities staff by 5.8% (current), 12.8% (1970, and 9.3% (1973).

The data reported in the "second" survey by the sample schools was extrapolated by the American Nuclear Society to the 183 schools that replied to the "first" survey. Some of the results of the extrapolated data were:

The rate of growth at the educational institutions of 34.4% between July 1969 and December 31, 1973.

2. A greater emphasis, percentagewise, on teaching and research and development activities associated with nuclear and reactor engineering, health physics, radiation applications, and radiation biology.
3. The number of reactor supervisors will be decreased by 10% of their current level.
4. An increase, percentagewise, in the hiring of BS's for R & D and nuclear facilities activities.
5. Between July 1969 and December 31, 1973, the total demand (growth and replacements) for nuclear degreed scientists and engineers by the educational institutions is 1,392 and 408 respectively.
6. The average annual incremental need for nuclear degreed scientists is 309.3; for nuclear degreed engineers, 90.7.

COMPARISON OF THE DATA PROVIDED BY THE SAMPLE SCHOOLS FOR BOTH THE "FIRST" AND "SECOND" SURVEYS

Of the 269 colleges and universities contacted in December 1967, 183 schools returned completed questionnaires (68.0%). Because the university survey was to be incorporated in the overall survey of technical manpower requirements of the atomic energy field and, because the other elements of the overall survey, namely, the in-depth interviews with private industry and the electric power utility survey were delayed in their completion, another survey of the educational institutions was undertaken to update the data. The updated survey consisted of sending to a sample of twenty-five (25) schools, the questionnaire they had completed in the "first" survey. These sample universities were asked to review their previous estimates in light of the current situation at their school and make corrections in their estimates if they felt their first estimates were no longer representative.

EDUCATIONAL INSTITUTIONS -
MANPOWER REQUIREMENTS

The updated survey, (hereafter known as the "second" survey), which was conducted during the months of July and August 1969, involved a select sample of 25 universities. Eighteen of these 25 schools responded to the "second" survey. Of these 18 schools, 4 schools reported no change in their manpower requirements and student enrollments given in the "first" survey. The remaining 14 schools revised their initial estimates.

The total number of current and planned for staff reported by the 18 sample schools in the "first" survey represented 34.2% of the total currently employed staff reported by the entire 183 schools in the "first" survey, 37.2% of the total estimated staff in 1970 and 36.9% of the total estimated staff in 1973. (Refer to Table 24 for a comparison of the data reported by the 18 sample schools in the "first" and "second" surveys.)

Comparison of these data show the sample schools reporting in the "second" survey increased the number of currently employed staff by 5.7% over what they had reported in the "first" survey. Their estimates of staff requirements for 1970 remained the same between the "first" and "second" surveys. However, in the "second" survey, the sample schools reported a 5.0% increase in their estimates of staff requirements for 1973 over what they had reported in the "first" survey.

In the "second" survey, the data reported by the sample schools showed, in five of the six activities listed in the questionnaire (faculty, full and part-time; research and development personnel, full and part-time; and, nuclear facilities personnel, full and part-time), a numerical increase in the number of currently employed personnel over what they reported in the "first" survey. The largest percentage increase occurred in the area of part-time research and development personnel (34.2%). The only decrease occurred in the area of full-time nuclear facilities personnel (5.8%).

Table 24

– EDUCATIONAL INSTITUTIONS –

COMPARISON OF DATA PROVIDED BY 183 REPORTING SCHOOLS IN THE INITIAL SURVEY AND REVISED DATA PROVIDED BY EIGHTEEN SAMPLE SCHOOLS IN THE SECOND STUDY.

Educational Institutions Staff Activities	1967-68			1968-69		1970					1973				
	Data for 183 Schools First Report	% of Total	Data for 18 Schools First Report	Data for 18 Schools 2nd Report	% Increase (Decrease) Between First and Second Report	Data for 183 Schools First Report	% of Total	Data for 18 Schools First Report	Data for 18 Schools 2nd Report	% Increase (Decrease) Between First and Second Report	Data for 183 Schools First Report	% of Total	Data for 18 Schools First Report	Data for 18 Schools 2nd Report	% Increase (Decrease) Between First and Second Report
TEACHING – Full-Time	1,023	32.5	291	303	4.1	1,262	34.8	392	385	(1.8)	1,472	34.8	476	480	0.8
TEACHING – Part-Time	410	13.0	146	151	3.4	414	11.4	179	188	5.0	452	10.7	196	212	8.2
R & D – Full-Time	842	26.8	352	371	5.4	929	25.6	406	405	--	1,116	26.4	441	468	6.1
R & D – Part-Time	402	12.8	79	106	34.2	467	12.9	118	136	15.3	525	12.4	136	183	34.6
NUCLEAR FACILITIES – Full-Time	309	9.8	138	130	(5.8)	371	10.2	172	150	(12.8)	438	10.4	215	195	9.3
NUCLEAR FACILITIES – Part-Time	158	5.1	69	75	8.7	186	5.1	82	84	2.4	226	5.3	98	102	4.1
TOTALS	3,144		1,075	1,136	5.7	3,629		1,349	1,348	*	4,229		1,562	1,640	5.0
STUDENT ENROLLMENTS	4,422		1,519	1,591	4.7	6,451		2,362	2,201	(6.8)	7,349		3,143	3,026	(3.7)

* Decrease, less than 0.1.

EDUCATIONAL INSTITUTIONS -
MANPOWER REQUIREMENTS

Although the total 1970 staff requirements estimated by the sample schools were the same for both the "first" and "second" surveys, specific requirements for part-time research and development personnel were increased by 15.3% in the "second" survey, while full-time nuclear facilities personnel requirements were decreased by 12.8% in the "second" survey.

Total staff requirements estimated by the sample schools for 1973 showed an increase of 78 employees in the "second" survey, the largest percent increase was for part-time research and development personnel (34.6%). The data reported by the sample schools in the "second" survey also showed a decrease in full-time nuclear facilities personnel (9.3%) over what they reported in the "first" survey.

An analysis of the data reported by the sample schools in the "second" survey over what they reported in the "first" survey indicates a decline in requirements for full-time nuclear facilities staff. This reduction may very well reflect the anticipated reduction of government funds for support of university research reactors. Another significant finding was an increase in the "second" survey of staff requirements for research and development activities. The increase was particularly evident for part-time research and development personnel, and this increase may reflect the universities' interim concern over possible reductions in government-sponsored fellowships, scholarships, etc. To financially assist those students who will be affected by reductions in fellowships, etc., the schools may be planning to employ, on a part-time basis, a larger number of these students in research activities that have already been funded. Or, in view of decreasing R & D funds, it may be that the universities are planning to economize their operations by reducing their full-time technician staff while substituting their students for technician-related R & D work.

REQUIREMENTS FOR FACULTY, RESEARCH AND DEVELOPMENT, AND NUCLEAR FACILITIES TECHNICAL PERSONNEL

Data reported for the "second" survey by the sample schools were extrapolated to the 183 schools replying to the "first" survey. Extrapolations from the sample schools to the 183 schools were made only for the totals of each of the six work activities. For example:

Full-Time Currently Employed R & D Personnel (183 schools - "first" survey) =842

Full-Time Currently Employed R & D Personnel (18 sample schools - "first" survey) =352

Full-Time Currently Employed R & D Personnel (18 sample schools - "second" survey) =371

$$\frac{352}{842} \div \frac{371}{X} = 887$$

Within each work activity, the American Nuclear Society extrapolated total was then broken down into the various disciplines or employment titles, by level of degree, using the percent distribution of the data reported by the 183 schools in the "first" survey.

The final data represent the requirements of 183 schools and not the requirements of the universe of 269 colleges and universities. The sample schools' data were not extrapolated to the entire universe of 269 schools because, after reviewing the 86 non-respondent schools and noting that they were generally small, liberal arts institutions with no graduate programs and especially no nuclear science and engineering programs, it was felt that the 183 surveyed schools represented more than 90% of the educational requirements for personnel who work in the atomic energy activities. It was also felt that the student enrollments in nuclear science and engineering at the 183 schools represent upwards of 95% of the total students enrolled in coursework leading to degrees in nuclear science and engineering. It was decided, therefore, to present data for only the 183 schools as it would be more representative of what is really happening in the educational community.

EDUCATIONAL INSTITUTIONS -
MANPOWER REQUIREMENTS

Data representing the number of faculty, by level of degree and discipline, currently employed and planned for teaching in the atomic energy field were obtained from the extrapolation by the American Nuclear Society of the sample survey to the 183 schools. (Refer to Table 25.) This Table includes the total number of currently employed full-time faculty and 50% of the reported 424 part-time faculty. For 1970 and 1973, respectively, Table 25 also includes 50% of the reported 435 and 489 planned for part-time teaching faculty.

Percentage increases between the number of currently employed faculty, teaching a specific nuclear science and engineering discipline, and the total number that will be required to teach each discipline in 1973 are:

Nuclear Science and Engineering Discipline	% Increase in Faculty Required Between July 1969 and Dec. 31, 1973	Number of Faculty Required Between July 1969 and Dec. 31, 1973
Thermonuclear Physics	120.7%	35
Other Nuclear Engineers	59.8%	61
Health Physics	46.9%	23
Radiation Application	41.5%	27
High Energy Physics	36.5%	91
Reactor Engineering	31.9%	44
Nuclear and Radiation Chemistry	27.1%	26
Radiation Biology	26.3%	26
Nuclear Physics	26.2%	118

Although faculty teaching nuclear physics are numerically the largest group reported, the trend, percentagewise, seems to be for more emphasis on the nuclear science and engineering disciplines. It is perhaps significant that 3 of the 4 disciplines that have the largest percent increases in faculty requirements between July 1969 and December 31, 1973 are more concerned with the applied engineering and

201
305

Table 25
– EDUCATIONAL INSTITUTIONS –

CURRENT (1969) EMPLOYMENT OF FACULTY TEACHING IN THE NUCLEAR FIELD BY LEVEL OF DEGREE AND NUCLEAR SCIENCE OR ENGINEERING DISCIPLINE BEING TAUGHT AND ANS PROJECTIONS OF FACULTY REQUIREMENTS FOR 1970 AND 1973 – Includes full-time FACULTY and 50% of the reported part-time FACULTY.

(Data include only faculty from schools which completed the ANS survey questionnaire and which offer degrees and/or courses in nuclear science and engineering. Data do not include full-time RESEARCH AND DEVELOPMENT or NUCLEAR FACILITIES PERSONNEL.)

DISCIPLINE	Currently Employed				Planned 1970				Planned 1973			
	PhD	MS	BS	Totals	PhD	MS	BS	Totals	PhD	MS	BS	Totals
Nuclear Physics	425	20	5	450 (35.2)	470	18	1	489 (33.6)	551	14	3	568 (32.9)
Thermonuclear Physics	29	–	–	29 (2.3)	52	–	–	52 (3.5)	64	–	–	64 (3.7)
High Energy Physics	248	1	–	249 (19.5)	285	1	–	286 (19.7)	340	–	–	340 (19.7)
Nuclear and Radiation Chemistry	89	6	1	96 (7.5)	93	4	2	99 (6.8)	115	4	3	122 (7.1)
Reactor Engineering	109	25	4	138 (10.8)	131	22	4	157 (10.8)	154	22	6	182 (10.5)
Other Nuclear Engineering	91	9	2	102 (8.0)	120	9	2	131 (9.0)	150	10	3	163 (9.4)
Radiation Applications	54	9	2	65 (5.1)	65	12	1	78 (5.4)	82	10	–	92 (5.3)
Health Physics	34	13	2	49 (3.8)	50	12	1	63 (4.3)	57	13	2	72 (4.2)
Radiation Biology	93	6	–	99 (7.8)	89	11	--	100 (6.9)	113	11	1	125 (7.2)
Totals	1,172	89	16	1,277 (100.0)	1,355	89	11	1,455 (100.0)	1,626	84	18	1,728 (100.0)
Totals by time period	1,277				1,455				1,728			

operational aspects of the atomic energy field rather than the basic research disciplines of nuclear physics, high energy physics, etc.

The extremely large percent increase in faculty teaching thermonuclear physics could be attributed not only to the fact that the numbers are relatively small but also to an anticipation of increased government activity in the development of nuclear power by fusion reactions.

As would be expected, the vast majority of the faculty have or will be required to have PhD degrees 91.8% (current), 93.1% (1970) and 94.1% (1973) . It is interesting to note, however, that by 1973 approximately 18.1% of the faculty teaching health physics, 12.1% teaching reactor engineering, and 10.9% teaching radiation applications will have only MS degrees. These percentages are well above the overall percentage of faculty with MS degrees 7.0% (current), 6.1% (1970), and 4.9% (1973)

Data for the 183 schools representing the number of R & D personnel currently employed, by level of degree and discipline being researched, and planned for employment in 1970 and 1973 is presented in Table 26. This Table includes the total number of full-time R & D personnel and 50% of the reported 539 currently employed part-time R & D personnel. Table 26 also includes, for 1970 and 1973, respectively, 50% of the reported 538 and 706 planned for part-time R & D personnel.

The percent increases between the number of currently employed R & D personnel, by the nuclear science and engineering discipline being researched, and the total number required by December 31, 1973 are:

Nuclear Science and Engineering Discipline	% Increase in R & D Personnel Required Between July 1969 and Dec. 31, 1973	Number of R & D Personnel Required Between July 1969 and Dec. 31, 1973
Thermonuclear Physics	194.1%	33
Radiation Biology	61.4%	43
Health Physics	58.1%	18

EDUCATIONAL INSTITUTIONS -
MANPOWER REQUIREMENTS

Nuclear Science and Engineering Discipline	% Increase in R & D Personnel Required Between July 1969 and Dec. 31, 1973	Number of R & D Personnel Required Between July 1969 and Dec. 31, 1973
Radiation Applications	56.8%	42
Other Nuclear Engineering	52.8%	47
Reactor Engineering	43.4%	23
Nuclear Physics	39.9%	119
Nuclear & Radiation Chemistry	11.8%	10
High Energy Physics	10.2%	45

Although the combined number of R & D personnel working in the areas of high energy physics and nuclear physics are numerically the largest disciplines in relation to the other disciplines 63.8% (current), 58.7% (1970), and 58.7% (1973) both rank in the bottom third of the disciplines listed by the percent increase in R & D personnel between July 1969 and December 31, 1973. In fact, R & D personnel working in high energy physics research actually declined from current employment to anticipated employment in 1970 by 12.7%. This decrease in high energy physics R & D personnel occurred primarily at the technician level.

It is evident that although research and development efforts will continue to be heavily concentrated in the areas of nuclear physics and high energy physics, the universities seem to anticipate increased research and development projects in other nuclear science and engineering disciplines. With the public's concern now being expressed over radiation safety, thermolpollution and ecology, it is interesting to note that the schools are responding by building up their research capacity and capability in radiation biology and health physics.

Percentage increases in the number of PhD's, MS's, BS's, and technicians currently employed and planned for employment by December 31, 1973 in R & D activities are:

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Table 26
– EDUCATIONAL INSTITUTIONS –

CURRENT (1969) EMPLOYMENT OF RESEARCH AND DEVELOPMENT PERSONNEL BY LEVEL OF DEGREE AND NUCLEAR SCIENCE AND ENGINEERING DISCIPLINE BEING INVESTIGATED AND ANS PROJECTIONS OF RESEARCH AND DEVELOPMENT PERSONNEL REQUIREMENTS FOR 1970 AND 1973 – Includes full-time RESEARCH AND DEVELOPMENT PERSONNEL and 50% of the reported part-time RESEARCH AND DEVELOPMENT PERSONNEL.

(Data include only research and development personnel from schools which completed the ANS survey questionnaire and which offer degrees and/or courses in nuclear science and engineering. Data do not include full-time FACULTY or NUCLEAR FACILITIES PERSONNEL.)

DISCIPLINE	Currently Employed					Planned 1970					Planned 1973				
	PhD	MS	BS	Tech	Totals	PhD	MS	BS	Tech	Totals	PhD	MS	BS	Tech	Totals
Nuclear Physics	138	43	33	84	298 (25.8)	158	41	35	84	318 (26.6)	212	58	50	97	417 (27.1)
Thermonuclear Physics	6	4	1	6	17 (1.4)	24	3	5	12	44 (3.6)	27	3	5	15	50 (3.3)
High Energy Physics	97	24	37	282	440 (38.0)	114	9	35	226	384 (32.1)	166	9	49	261	485 (31.6)
Nuclear and Radiation Chemistry	57	8	4	16	85 (7.3)	56	1	6	16	79 (6.6)	59	7	10	19	95 (6.2)
Reactor Engineering	14	15	7	17	53 (4.6)	13	16	10	23	62 (5.2)	25	15	11	25	76 (4.9)
Other Nuclear Engineering	13	24	24	28	89 (7.7)	13	31	25	29	98 (8.2)	17	41	41	37	136 (8.8)
Radiation Applications	26	19	8	21	74 (6.4)	24	21	15	28	88 (7.4)	30	26	24	36	116 (7.5)
Health Physics	9	7	6	9	31 (2.7)	10	9	8	10	37 (3.1)	12	10	9	18	49 (3.2)
Radiation Biology	26	9	6	29	70 (6.1)	32	6	11	37	86 (7.2)	38	12	16	47	113 (7.4)
Totals	386	153	126	492	1,157	444	137	150	465	1,196	586	181	215	555	1,537
Totals by time period	1,157					1,196					1,537				

EDUCATIONAL INSTITUTIONS -
MANPOWER REQUIREMENTS

Level of Degree	% Increase of R & D Personnel Required Between July 1969 and Dec. 31, 1973	Numerical Increase in R & D Personnel Required Between July 1969 and Dec. 31, 1973
PhD's	51.8%	200
MS's	18.3%	28
BS's	70.6%	89
Technicians	12.8%	63

It is interesting to see how the universities retain their PhD personnel when government research funds are cutback. The PhD's are retained, apparently, at the expense of full-time R & D technicians who can be easily replaced by graduate students at considerably less operating expense to the schools.

Data for the 183 schools representing the number of nuclear facilities personnel currently employed and planned for employment in 1970 and 1973 by level of degree and employment title, are presented in Table 27. This Table includes the total number of full-time nuclear facilities personnel and 50% of the reported 172 currently employed part-time nuclear facilities personnel.

The Table also includes, for 1970 and 1973 respectively, 50% of the reported 191 and 235 planned for part-time nuclear facilities personnel.

Percentage increases between the number of nuclear facilities personnel currently employed and planned for employment in 1973, by employment title, are:

Employment Title	% Increase in Nuclear Facilities Personnel Required Between July 1969 and Dec. 31, 1973	Numerical Increase in Nuclear Facilities Personnel Required Between July 1969 and Dec. 31, 1973
Accelerator Operators	56.1%	55
Reactor Operators	46.3%	44
Radiation Safety Officers	34.5%	30
Accelerator Supervisors	27.1%	13
Reactor Supervisors	-10.0%	-5

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Table 27
– EDUCATIONAL INSTITUTIONS

CURRENT (1969) EMPLOYMENT OF NUCLEAR FACILITIES PERSONNEL BY LEVEL OF DEGREE AND EMPLOYMENT TITLE AND ANS PROJECTIONS OF NUCLEAR FACILITIES PERSONNEL REQUIREMENTS FOR 1970 AND 1973 – Includes full-time NUCLEAR FACILITIES PERSONNEL and 50% of the reported part-time NUCLEAR FACILITIES PERSONNEL. (Data include only nuclear facilities personnel from schools which completed the ANS survey questionnaire and which offer degrees and/or courses in nuclear science and engineering. Data do not include full-time FACULTY or RESEARCH AND DEVELOPMENT PERSONNEL.)

AREA	Currently Employed					Planned 1970					Planned 1973				
	PhD	MS	BS	Tech	Totals	PhD	MS	BS	Tech	Totals	PhD	MS	BS	Tech	Totals
Reactor Supervisors	7	27	10	6	50 (13.2)	5	20	16	5	46 (11.0)	6	17	16	6	45 (8.8)
Reactor Operators	5	12	20	58	95 (25.1)	7	15	30	75	127 (30.3)	7	14	33	85	139 (27.0)
Accelerator Supervisors	9	8	10	21	48 (12.7)	10	10	9	21	50 (11.9)	13	16	8	24	61 (11.8)
Accelerator Operators	2	6	22	68	98 (25.9)	5	15	19	69	108 (25.8)	5	29	21	98	153 (29.7)
Radiation Safety Officer (Health Physicist)	16	28	22	21	87 (23.1)	14	28	24	22	88 (21.0)	13	30	38	36	117 (22.7)
Totals	39	81	84	174	378	41	88	98	192	419	44	106	116	249	515
Totals by time period	378					419					515				

Not only are accelerator and reactor operators numerically the largest groups reported but they also rank first and second in the percent increase between July 1969 and December 31, 1973. Of the 99 individuals that will be hired to fill new positions as either accelerator or reactor operators, 57.6% will be technician-level personnel.

Reactor supervisory personnel will decrease by 10% between 1969 and 1973. These reductions will only occur with degreed personnel (1 PhD and 10 MS's). Employment of BS degree holders will increase by 60% (6) in reactor supervisory roles while technician level personnel will remain the same.

There will be a net increase of 13 accelerator supervisors between July 1969 and December 31, 1973. Twelve new positions will open for degreed personnel (4 PhD's and 8 MS's); 2 BS degreed individuals currently employed as reactor supervisors will be lost resulting in a net gain of 10 new accelerator supervisory positions.

Half of the projected 30 new radiation safety officer (health physicists) positions will be filled by degreed personnel. Although 3 PhD's will be lost, 2 MS's, and 16 BS's will be hired resulting in a net gain of 15 degreed radiation safety officers. The remaining 15 new positions will be filled by technician-level personnel.

Percentage increases in the number of PhD's, MS's, BS's, and technicians currently employed and planned for employment in 1973 in nuclear facilities activities are:

EDUCATIONAL INSTITUTIONS -
MANPOWER REQUIREMENTS

Level of Degree	% Increase in Nuclear Facilities Personnel Required Between July 1969 and Dec. 31, 1973	Numerican Increase in Nuclear Facilities Personnel Required Between July 1969 and Dec. 31, 1973
PhD's	12.8%	5
MS's	30.9%	25
BS's	38.1%	32
Technicians	43.1%	75

Data concerning the universities' requirements for reactor operators and supervisors seems to be inconsistent (increasing operators and decreasing supervisors). In 1969, for example, the ratio of reactor operators to supervisors was 1.9/1 while the projected ratio for 1973 is 3.1/1. A possible explanation for inconsistency is that the schools are attempting to readjust their operating budgets in anticipation of reduced government support of research reactors. In effect, by reducing their supervisory personnel, they are reducing their direct costs.

To arrive at the total technical manpower requirements of the educational institutions active in the atomic energy field, it was assumed that all new faculty, research and development, and nuclear facilities personnel positions that required degreed individuals would be filled with nuclear degreed scientists and engineers. It was also assumed that not only will all growth-related positions be filled with nuclear-degreed personnel but also all replacement positions.

The overall growth in technical manpower requirements of the 183 surveyed schools during the period extending from July 1969 through December 31, 1973 was calculated to be 34.4% or a total of 968 new technical positions.

Percentage increase in the number of scientists, engineers and technicians that will be required between July 1969 and December 31, 1973 are:

EDUCATIONAL INSTITUTIONS - MANPOWER REQUIREMENTS

Categories of Technical Personnel	% Increase in Technical Manpower Requirements Between July 1969 and Dec. 31, 1973	Numerical Increase in Technical Manpower Requirements Between July 1969 and Dec. 31, 1973
Engineers	43.2%	205
Scientists	37.4%	625
Technicians	20.7%	138

Although the requirements for scientists are numerically larger, the requirements for engineers have the largest percentage increase. The fact that the educational institutions are increasing their engineering staff at a rate greater than that for scientists may be due to an increased awareness of industry's perference for graduates trained in engineering rather than in science disciplines.

The percent increase in the total staff requirements, by level of degree, between July 1969 and December 31, 1973 are:

Level of Degree	% Increase in Technical Manpower Requirements Between July 1969 and Dec. 31, 1973	Numerical Increase in Technical Manpower Requirements Between July 1969 and Dec. 31, 1973
PhD's	41.3%	659
MS's	14.9%	48
BS's	54.4%	123
Technicians	20.7%	138

These data again point out the continuing emphasis on hiring PhD's, especially for faculty positions, and an increased emphasis on hiring BS's for work in R & D and nuclear facilities activities.

When considering the breakdown of the educational institutions' staff requirements by work activity, the following percent increases were calculated for the time period extending from July 1969 through December 31, 1973:

EDUCATIONAL INSTITUTIONS -
MANPOWER REQUIREMENTS

Work Activity	% Increase in Technical Manpower Requirements Between July 1969 and Dec. 31, 1973	Numerical Increase in Technical Manpower Requirements Between July 1969 and Dec. 31, 1973
Nuclear Facilities Personnel	36.2%	137
Faculty	35.3%	451
R & D Personnel	32.8%	380

A graphical representation of the overall technical manpower growth of the educational institutions by work activity is presented in Chart 18.

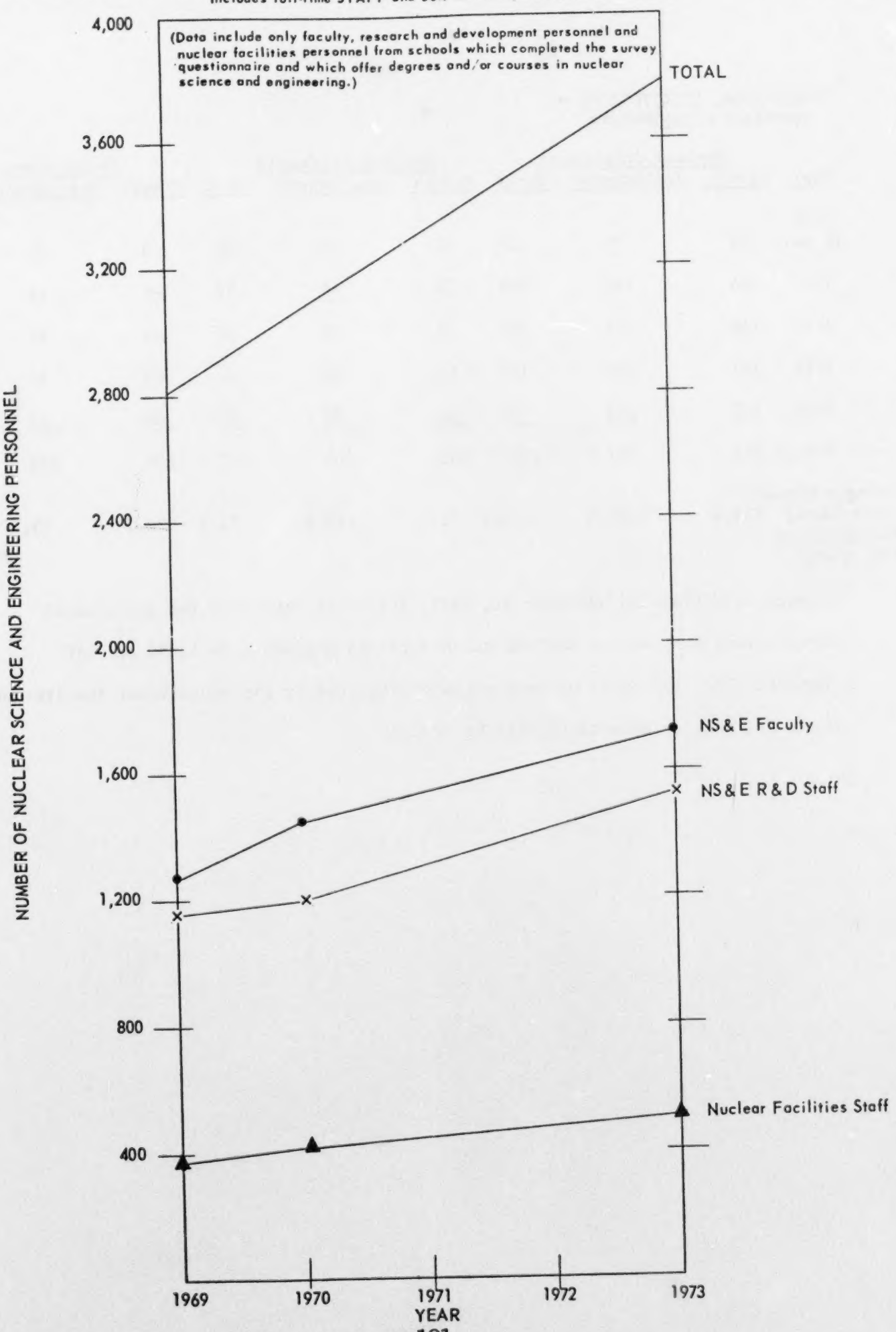
If all new non technician-level positions are filled with nuclear degreed scientists and engineers, the annual incremental needs will be:

Year	Annual Incremental Requirements for Nuclear Degreed Personnel to Fill New Positions	
	Scientists	Engineers
1969 (6 mo.)	61	27
1970	124	55
1971	146	41
1972	147	41
1973	147	41

In addition to the educational institutions' requirements for nuclear degreed scientists and engineers to fill new positions, allowances for attrition must also be included to arrive at the total technical manpower requirements of the universities. (Allowances for attrition are the same as those used previously in this report: 8.4% for scientists; 7.6% for engineers; and, 11.0% for technicians.)

Chart 18

COMPARISON OF THE CURRENT (1969) AND PLANNED FOR (1970-1973) EDUCATIONAL INSTITUTIONS' NUCLEAR SCIENCE AND ENGINEERING FACULTY, RESEARCH AND DEVELOPMENT PERSONNEL AND NUCLEAR FACILITIES PERSONNEL – Includes full-time STAFF and 50% of the reported part-time STAFF.



EDUCATIONAL INSTITUTIONS -
MANPOWER REQUIREMENTS

	Nuclear Scientists			Nuclear Engineers			Technicians		
Year	Growth	Replacement	Total	Growth	Replacement	Total	Growth	Replacement	Total
1969 (6 mo.)	61	70	131	27	18	45	-3	37	34
1970	124	156	280	55	42	97	-6	61	55
1971	146	168	314	41	45	86	49	65	114
1972	147	180	327	41	48	89	49	70	119
1973	147	193	340	41	52	93	49	75	124
TOTALS	625	767	1,392	205	205	410	138	308	446
Average Annual Incremental Requirements (4½ years)	138.9	170.4	309.3	45.1	45.6	91.1	30.7	68.4	99.1

Between July 1969 and December 31, 1973, the total demand by the educational institutions for nuclear degreed scientists and engineers is 1,392 and 410 respectively. For every nuclear engineer required by the educational institutions, about 3.4 nuclear scientists will be needed.

CURRENT AND PROJECTED SUPPLY OF NUCLEAR DEGREED SCIENTISTS AND ENGINEERS

COMPARISON OF THE DATA PROVIDED BY THE SAMPLE SCHOOLS FOR BOTH THE "FIRST" AND "SECOND" SURVEYS

As has been previously described, a "second" survey to bring the data up-to-date was conducted with a sample of 25 universities that had participated in the "first" survey. Eighteen of these schools replied to the "second" survey. Four of the reporting schools indicated no change in their estimates of student enrollments in nuclear science and engineering. The remaining 14 schools revised the estimates they had given in the "first" survey.

The total number of current and planned for student enrollments in coursework leading to degrees in nuclear science or engineering that were reported by the sample schools in the "first" survey represented 34.3% of the total current student enrollments reported by the 183 schools, 36.6% for 1970 and 42.8% for 1973. (Refer to Table 24 for a comparison of the data reported by the sample schools for both the "first" and "second" surveys.)

Comparison of the student enrollment data shows that the sample schools increased their current student enrollment figures by 4.7% in the "second" survey over what they had reported in the "first" survey. In addition, the sample schools in the "second" survey, decreased the student enrollment estimates they gave in the "first" report by 6.8% and 3.7% for 1970 and 1973 respectively.

ESTIMATES OF STUDENT ENROLLMENTS IN COURSEWORK LEADING TO DEGREES IN NUCLEAR SCIENCE OR ENGINEERING

Data reported by the sample schools in the "second" survey were extrapolated by the American Nuclear Society to the 183 schools replying to the "first" survey. Extrapolations were only made for the total enrollments for each time period (Current, 1970, and 1973). For example:

EDUCATIONAL INSTITUTIONS -
MANPOWER SUPPLY

Number of Students Currently Enrolled (183 schools - "first" report) = 4,422

Number of Students Currently Enrolled (18 sample schools - "first" report) = 1,519

Number of Students Currently Enrolled (18 sample schools - "second" report) = 1,591

$$\frac{1,519}{4,422} \div \frac{1,591}{X} = 4,632$$

The extrapolated totals were then broken down into the 9 nuclear science and engineering disciplines listed in the questionnaire using the percent distribution of the data initially reported by the 183 schools. The resultant data are presented in Table 28.

The data show that between June 1969 and December 31, 1973, student enrollments in nuclear science and engineering will increase by 52.7% (2,443). The breakdown of the percent increases between current enrollments and estimated enrollments in 1973 by nuclear science and engineering discipline are:

Nuclear Science and Engng. Discipline	% Increase in Student Enrollments Between July 1969 and Dec. 31, 1973	Numerical Increase in Student Enrollments Between July 1969 and Dec. 31, 1973
Radiation Biology	93.6%	147
Thermonuclear Physics	76.1%	67
Nuclear and Radiation Chemistry	65.0%	184
Reactor Engineering	57.9%	560
Other Nuclear Engineering	50.7%	526
Nuclear Physics	47.3%	620
High Energy Physics	47.1%	229
Radiation Application	40.9%	74
Health Physics	30.0%	36

Although student enrollments in nuclear physics show the largest numerical increase, it ranks only sixth in percentage increase. The significance of the data lies in the large increase, both numerically and percentagewise, in student enrollments n nuclear and reactor engineering disciplines.

Table 28

– EDUCATIONAL INSTITUTIONS –

CURRENT (1969) ENROLLMENT OF STUDENTS IN COURSEWORK LEADING TO DEGREES IN NUCLEAR SCIENCE OR ENGINEERING BY LEVEL OF DEGREE EARNED AND NUCLEAR SCIENCE OR ENGINEERING DISCIPLINE IN WHICH DEGREE WAS EARNED AND ANS PROJECTIONS OF STUDENT ENROLLMENTS FOR 1970 AND 1973.

(Data include only student enrollments from schools which completed the ANS survey questionnaire and which offer degrees and/or courses in nuclear science and engineering.)

DISCIPLINE	Current				Planned 1970				Planned 1973			
	PhD	MS	BS	Totals	PhD	MS	BS	Totals	PhD	MS	BS	Totals
Nuclear Physics	653	221	437	(28.3) 1,311	739	352	484	(26.2) 1,575	896	436	599	(27.3) 1,931
Thermonuclear Physics	63	15	10	(1.9) 88	100	34	12	(2.4) 146	129	21	5	(2.2) 155
High Energy Physics	423	41	22	(10.5) 486	501	56	20	(9.6) 577	621	69	25	(10.1) 715
Nuclear and Radiation Chemistry	116	63	104	(6.1) 283	163	79	137	(6.3) 379	219	91	157	(6.6) 467
Reactor Engineering	229	277	462	(20.9) 968	278	370	704	(22.5) 1,352	344	405	779	(21.6) 1,528
Other Nuclear Engineering	223	356	459	(22.4) 1,038	276	442	634	(22.5) 1,352	365	430	769	(22.1) 1,564
Radiation Applications	85	66	30	(3.9) 181	99	81	36	(3.6) 216	137	93	25	(3.6) 255
Health Physics	55	64	1	(2.6) 120	58	74	42	(2.9) 174	70	58	28	(2.2) 156
Radiation Biology	52	67	38	(3.4) 157	90	103	47	(4.0) 240	123	108	73	(4.3) 304
Totals	1,899	1,170	1,563	4,632	2,304	1,591	2,116	6,011	2,904	1,711	2,460	7,075
Totals by time period	4,632				6,011				7,075			

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EDUCATIONAL INSTITUTIONS -
MANPOWER SUPPLY

Percentage increases in student enrollments by level of degree being sought are:

Level of Degree	% Increase in Student Enrollments Between July 1969 and Dec. 31, 1973	Numerical Increase in Student Enrollments Between July 1969 and Dec. 31, 1973
PhD's	52.9%	1,005
MS's	46.2%	541
BS's	57.4%	897

Although the schools will continue to place emphasis on PhD candidates they are apparently planning to build up their nuclear science and engineering programs at the BS level.

ESTIMATES OF THE ANNUAL SUPPLY OF GRADUATED NUCLEAR SCIENTISTS AND ENGINEERS WHO WILL ENTER THE WORK FORCE

In order to translate student enrollments in nuclear science and engineering disciplines into estimates of the annual supply of nuclear science and engineering graduates who will be available for employment in the atomic energy field, a telephone survey was conducted by the American Nuclear Society during the week of February 2, 1970. Eighteen major nuclear science and engineering degree granting universities were contacted. The telephone survey consisted of the same four questions for each level of degree. The data requested was limited to the 1968-1969 academic year. The questions asked and the data collected from the 18 schools were:

1) How many students were enrolled in coursework leading to a degree in nuclear science or engineering?

Level of Degree	Student Enrollments
PhD's	353
MS's	405
BS's	544
TOTAL	1,302

2) How many students were conferred degrees in nuclear science or engineering?

Level of Degree	Number of Degrees Conferred
PhD's	97
MS's	184
BS's	88
TOTAL	369

3) How many students who receive a degree in nuclear science or engineering enrolled in coursework leading to an advanced degree in nuclear science or engineering or, in the case of graduating PhD's, to post-graduate study?

Level of Degree Conferred	Number Enrolled in Advanced Nuclear Science or Engineering Degree Programs
PhD's	5
MS's	63
BS's	23
TOTAL	91

4) Approximately how many graduating nuclear science and engineering students were drafted or voluntarily joined the military service?

Level of Degree Conferred	Number Drafted or Voluntarily Joined the Military
PhD's	1
MS's	28
BS's	13
TOTAL	42

From these data, the following percentages were calculated:

1) Percentage of graduating nuclear science and engineering students to the total number of students enrolled by level of degree.

Level of Degree	% of Graduates to Total Student Enrollments
PhD's	27.5%

EDUCATIONAL INSTITUTIONS -
MANPOWER SUPPLY

Level of Degree	% of Graduates to Total Student Enrollments
MS's	45.4%
BS's	16.2%

2) Percentage of the total number of graduating nuclear science and engineering students who enrolled in advanced nuclear science or engineering degree programs.

Level of Degree	% of Graduates Entering Advanced Degree Programs
PhD's	5.2% (Post-graduate)
MS's	34.2%
BS's	26.1%

3) Percentage of the total number of graduating nuclear science and engineering students who were drafted or voluntarily joined the military service.

Level of Degree	% of Graduates Who Went Into The Military Service
PhD's	1.0%
MS's	15.2%
BS's	14.8%

Another important factor affecting the available work force is the percentage of all students enrolled in nuclear science and engineering who are foreign nationals and, the percentage of all conferred MS and PhD degrees in nuclear science and engineering that are foreign students who will return to their home country or a country other than the U.S. This information was obtained from Dr. A. David Rossin's study of "Foreign Students Obtained MS and PhD Degrees at American Universities (1952-1967)." In this study, Dr. Rossin included nuclear engineering degrees granted through June 1967. The percentage of foreign students to the total number of MS degrees granted in nuclear engineering was 14.7%. The percentage of

Table 29

COMPARISON OF THE CURRENT (1969-SIX MOS.) AND PROJECTED (1970, 1973) ANNUAL SUPPLY OF NUCLEAR OR REACTOR ENGINEERS TO THE ESTIMATED DEMAND FOR THESE ENGINEERING TYPES BY PRIVATE INDUSTRY, ELECTRIC POWER UTILITIES AND EDUCATIONAL INSTITUTIONS.

(Supply data refer only to graduating nuclear or reactor engineers from schools which completed the ANS survey questionnaire and which offer degrees and/or courses in nuclear science and engineering. Demand data do not include requirements for nuclear or reactor engineers by government-owned-contractor-operated organizations, national laboratories, defense production facilities and federal services.)

	1968 – 1969			1969 – 1970			1970 – 1971			1971 – 1972			1972 – 1973		
	PhD	MS	BS	PhD	MS	BS	PhD	MS	BS	PhD	MS	BS	PhD	MS	BS
Current and Projected Enrollments of Nuclear or Reactor Engineering Students	452	633	921	554	812	1338	605	819	1408	656	827	1478	709	835	1548
Total Number of Annual Degrees Conferred in Nuclear or Reactor Engineering[1] (Foreign)[2] (U.S. Graduates – Total)	124 – 25 99	287 – 42 245	149	152 – 31 121	369 – 54 315	217	166 – 34 132	372 – 55 317	228	180 – 37 143	375 – 55 320	239	195 – 40 155	379 – 56 323	251
Total Number of Annual Nuclear or Reactor Engineering Graduates Who Will Enroll In Advanced Degree Programs[3]	6	98	39	8	126	57	9	127	60	9	128	62	10	130	66
Total Number of Annual Nuclear or Reactor Engineering Graduates Who Will Be Drafted or Voluntarily Enlist in Military Service[4]	1	37	22	1	48	32	1	48	34	1	49	35	2	49	37
Total Number of Annual Nuclear or Reactor Engineering Foreign Graduates Who Will Return To Their Home or Third Country[5]	11	32	--	14	41	--	15	41	--	16	41	--	18	42	--
Total Number of Annual Nuclear or Reactor Engineering Graduates Who Will Be Available for Employment in the Atomic Energy Field	106	120	88	129	154	128	141	156	134	154	157	142	165	158	148
Total New Positions for Nuclear or Reactor Engineers Available at Private Industry, Electric Utilities & Educational Institutions	36	61	44	73	124	88	55	84	61	55	85	61	56	87	59
Allowances for Attrition of Nuclear or Reactor Engineers (7.6%/yr.)[6]	39	57	31	47	71	40	51	78	44	56	85	50	60	90	55
Total Annual Requirements for Nuclear or Reactor Engineers for Private Industry, Electric Utilities & Educational Institutions[7]	75	118	75	120	195	128	106	162	105	111	170	111	116	177	114
APPARENT SUPPLY-DEMAND DIFFERENCE +	31	2	13	9		--	35		29	43		31	49		34
APPARENT SUPPLY-DEMAND DIFFERENCE –					41			6			13			19	

1. The percentage of PhD graduating students to total PhD enrollments was calculated to be 27.5%; MS: 45.4%; and, BS: 16.2%.
2. The percentage of graduating foreign students to total graduates at the PhD level was calculated to be 20.4%; MS: 14.7%.
3. The percentage of graduating PhD students who will continue their education (Post-Doctoral) to the total number of graduating PhD's was calculated to be 5.2%; MS: 34.2%; and, BS: 26.1%.
4. The percentage of graduating PhD students who will be drafted or voluntarily join the military service to the total number of graduating PhD's was calculated to be 1.0%; MS: 15.2%; and, BS: 14.8%.
5. Percentages derived from A. David Rossin's Survey of Foreign Students Obtaining MS and PhD's at American Universities (1952 – 1967).
6. 7.6% rate of attrition based upon the following factors (%): Retirements and Deaths = 4.0%; Educational Updating While Employed = 2.0%; and, Turnover and Transfers = 1.6%. These factors and percentages were obtained from BLS Technical Note *(Monthly Labor Review*, November 1966.
7. Total annual requirements for nuclear or reactor engineers for the period 1968 – 1969 is calculated for a six month period ONLY.

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Table 30

ARISON OF THE CURRENT (1969-SIX MOS.) AND PROJECTED (1970, 197. UAL SUPPLY OF NUCLEAR OF NUCLEAR SCIENTISTS TO THE ESTIMA. EMAND FOR THESE SCIENTIFIC TYPES BY PRIVATE INDUSTRY, ELECTRIC POWER UTILITIES AND EDUCATIONAL INSTITUTIONS.

(Supply data refer only to graduating nuclear scientists from schools which completed the ANS survey questionnaire and which offer degrees and/or courses in nuclear science and engineering. Demand data do not include requirements for nuclear scientists by government-owned-contractor-operated organizations, national laboratories, defense production facilities and federal services.)

	1968 - 1969			1969 - 1970			1970 - 1971			1971 - 1972			1972 - 1973		
	PhD	MS	BS	PhD	MS	BS	PhD	MS	BS	PhD	MS	BS	PhD	MS	BS
Current and Projected Enrollments of Nuclear Scientists	1447	537	642	1750	779	778	1898	811	822	2046	843	867	2195	876	912
Total Number of Annual Degrees Conferred in Nuclear Science [1] (Foreign) [2]	398 -81	244 -36	104	481 -98	354 -52	126	522 -106	368 - 54	133 -	553 -113	383 - 56	140	604 -123	398 - 59	148
(U.S. Graduates – Total)	317	208		383	302		416	314		440	327		481	339	
Total Number of Annual Nuclear Science Graduates Who Will Enroll in Advanced Degree Programs [3]	21	83	27	25	121	33	27	126	35	29	131	37	31	136	39
Total Number of Annual Nuclear Science Graduates Who Will Be Drafted or Voluntarily Enlist in the Military Service [4]	3	32	15	4	46	19	4	48	20	4	50	21	5	52	22
Total Number of Annual Nuclear Science Foreign Graduates Who Will Return To Their Home or Third Country [5]	36	27	--	43	39	--	47	41	--	50	42	--	54	44	--
Total Number of Annual Nuclear Science Graduates Who Will Be Available for Employment in the Atomic Energy Field	338	102	62	409	148	74	444	153	78	470	160	82	514	166	87
Total New Positions for Nuclear Scientists at Private Industry, Electric Utilities and Educational Institutions	75	30	20	152	63	42	136	59	44	137	61	45	139	62	45
Allowances for Attrition of Nuclear Scientists (8.4%) [6]	127	49	24	146	53	28	157	57	31	169	62	35	181	69	40
Total Annual Requirements for Nuclear Scientists for Private Industry, Electric Utilities and Educational Institutions [7]	202	79	44	298	116	70	293	116	75	306	123	80	320	131	95
APPARENT SUPPLY-DEMAND DIFFERENCE + –	136	23	18	111	32	4	151	37	3	164	37	2	194	35	8

1. – 5. See explanation of table concerned with nuclear or reactor engineers.

6. 8.4% rate of attrition based upon the following factors (%): Retirements and Deaths = 4.0%; Educational Updating While Employed = 2.0%; and Turnover and Transfers = 2.4%.

7. Total annual requirements for nuclear scientists for the period 1968 - 1969 is calculated for a six month period only.

graduating PhD's in nuclear engineering who were foreign students was 20.4%.

Using the data from the Rossin study, percentages of the foreign students who would leave the U.S. were calculated. Approximately 75.1% of the graduating foreign students with MS's in nuclear engineering returned to their own country or a country other than the U.S. At the PhD level, 55.9% of the graduating foreign students in nuclear engineering left the U.S.

These percentages were applied to the estimated student enrollments in nuclear science and engineering for the 183 schools (Table 28) to arrive at the total number of annual graduating nuclear or reactor engineering (Table 29) and nuclear science (Table 30) students who will be available for employment in the atomic energy field.

Analysis of the data show that during the period extending from June 1969 through December 31, 1973, 5,367 nuclear science and engineering graduates will enter the work force of the atomic energy field. The average number of graduating nuclear science and engineering students entering the work force is 1,073/year - by level of degree the averages are: PhD's - 574/yr.; MS's - 295/yr.; and BS's - 205/yr.

EVALUATION OF TECHNICAL MANPOWER OF SELECTED SEGMENTS OF THE ATOMIC ENERGY FIELD (1969-1973)

COMPARISON OF THE SUPPLY AND DEMAND FOR NUCLEAR DEGREED SCIENTISTS AND ENGINEERS

In this section of the report, the comparison of the supply and demand for nuclear degreed scientists and engineers refers only to the manpower demands of selected private industries, electric utilities, educational institutions and GOCO facilities. The demand for nuclear degreed scientists and engineers is based on the premise that these individuals must spend at least 50% of their working time in atomic energy activities. Also, only one-half of the attrition requirements of GOCO facilities has been included.

Table 31 presents the current employment of nuclear degreed scientists and engineers at only private industries, electric power utilities and educational institutions and ANS projections of their requirements for nuclear degreed individuals for 1970 and 1973. These data represent only their requirements for nuclear degreed scientists and engineers to fill new positions and does not include allowances for attrition. The demand data for nuclear degreed individuals is somewhat overstated as it was assumed that all new positions requiring degreed scientists and engineers at the educational institutions covered in this study would be filled by nuclear degreed personnel. Likewise, it was also assumed that all graduating nuclear science and engineering students who are available for employment would enter the atomic energy field. It is felt, however, that these assumptions would essentially cancel each other out and the effect upon the data would be negligible.

The growth in demand by private industries, electric power utilities and educational institutions active in the atomic energy field for nuclear degreed scientists and engineers between July 1969 and December 31, 1973 is 52.7%. The growth in demand for nuclear degreed scientists during this period of time is 46.0%.

The growth in demand for nuclear degreed engineers during this period is 62.2%.

Tables 29 and 30 show the comparison of the current and ANS projected annual supply of nuclear degreed scientists and engineers to the estimated annual demand for these types by private industries, electric power utilities and educational institutions during the period extending from July 1969 through December 31, 1973. The supply data represent graduating nuclear-degreed scientists and engineers who will actually be available for employment in the atomic energy field. Also, the demand data represents requirements for nuclear-degreed individuals to fill not only new positions but also replacement positions.

Chart 19 shows the relationship between the total estimated supply of nuclear degreed scientists and engineers to that part of the estimated demand for these types by private industries, electric power utilities, educational institutions, and GOCO facilities. Charts 20, 21, and 22 show the relationship between the total estimated supply of nuclear degreed scientists and engineers, by level of degree, and the total estimated demand for nuclear degreed scientists and engineers, by level of degree.

Analyses of these charts show an apparent availability of nuclear degreed individuals and, in particular, an excess of nuclear degreed scientists at the PhD level. In fact, the estimated output of these individuals is growing at a rate exceeding the estimated demand (note the relative stability of the demand for these types between 1970 and 1973). With regard to nuclear degreed engineers, the situation is somewhat different. At the PhD level, the disparity between the estimated supply and demand for nuclear degreed engineers is relatively small and, in the case of the BS and MS level nuclear degreed engineer, their demand is greater than the estimated supply.

Table 31

CURRENT (1969) EMPLOYMENT OF NUCLEAR-DEGREE SCIENTISTS AND ENGINEERS AT PRIVATE INDUSTRY, ELECTRIC POWER UTILITIES AND EDUCATIONAL INSTITUTIONS AND ANS PROJECTIONS OF THEIR REQUIREMENTS FOR THESE TYPES FOR 1970 AND 1973.

(Data include only nuclear-degree scientists and engineers who spend or will spend at least 50% of their working time in atomic energy activities. Data do not include requirements for nuclear-degree scientists and engineers by government-owned-contractor-operated organizations, national laboratories, defense production facilities and federal services.)

OCCUPATIONAL CATEGORIES	CURRENT EMPLOYMENT	1970	INCREASE/ DECREASE	1973	INCREASE/ DECREASE
SCIENTISTS (Life & Physical)	2365	2725	+360	3454	+729
ENGINEERS	1655	2081	+426	2684	+603
TOTALS	**4020**	**4806**	**+786**	**6138**	**+1332**

(1) Figures include the educational institutions' currently employed and planned for scientists and engineers who may or may not have degrees in Nuclear Science or Engineering. For purposes of the study, it was assumed that all new degree positions at the educational institutions will be filled with Nuclear degree holders.

In addition to the private industries, electric power utilities and educational institutions, there are other major employment markets for nuclear degreed individuals. In fact, GOCO organizations (the national laboratories and defense production facilities) and state and federal services have historically been the primary employers of nuclear degreed scientists and engineers. None of these were included in the study itself. Under normal circumstances these employment markets (especially the national labs) would more than account for the difference between supply and demand indicated above.. However, the key phrase is "under normal circumstances. With drastic cuts in government funds for research in the atomic energy field, these employment markets, at least in the near future, will not constitute a major source of demand for scientists or engineers in general or of nuclear degreed scientists and engineers in particular. Therefore, GOCO demands included in charts 19 - 22 provide for no growth and only 50% of estimated normal attrition.

In an attempt to substantiate the employment outlook at the national laboratories, the American Nuclear Society conducted a telephone survey with 4 national labs. The 5 questions asked were:

1) How many scientists and engineers are currently employed at your laboratory?
2) What percentage (or how many) of your currently employed scientists and engineers received their degrees specifically in nuclear science or engineering?
3) About how many nuclear degreed scientists and engineers does your laboratory normally hire each year?
4) Do you expect to maintain this rate of employment for nuclear degreed individuals during the next four years?

Chart 19

COMPARISON OF THE CURRENT (1969 - 6 MO.) AND ANS PROJECTED (1970-1973) ANNUAL SUPPLY OF GRADUATING NUCLEAR SCIENTISTS AND ENGINEERS TO THE ANS ESTIMATED ANNUAL DEMAND FOR THESE TYPES BY PRIVATE INDUSTRY, ELECTRIC UTILITIES, EDUCATIONAL INSTITUTIONS AND GOCO FACILITIES.

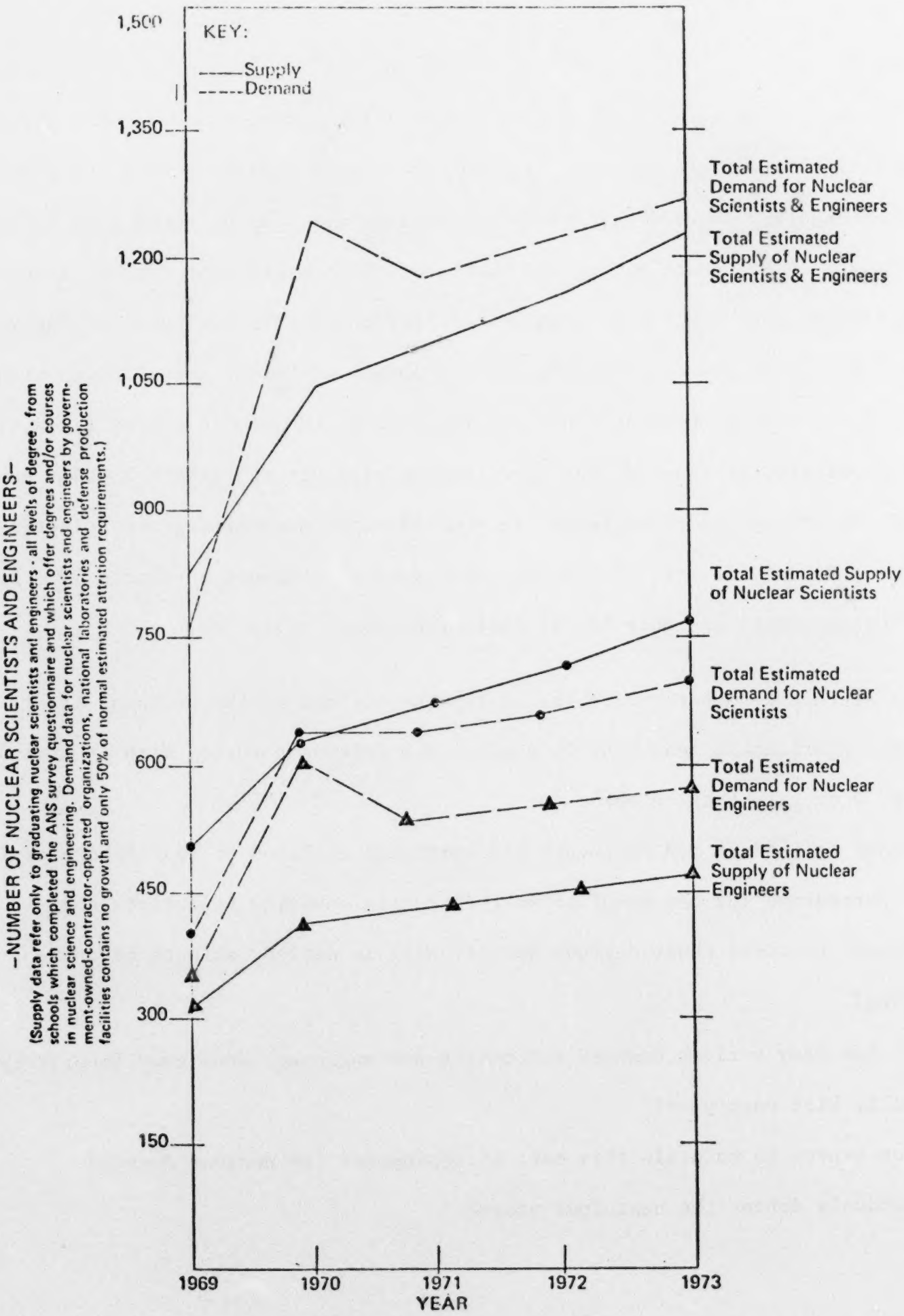

KEY:
Supply
Demand
1,500
1,350
1,200
1,050
900
750
600
450
300
150
1969
1970
1971
1972
1973
YEAR
Total Estimated Demand for Nuclear Scientists & Engineers
Total Estimated Supply of Nuclear Scientists & Engineers
Total Estimated Supply of Nuclear Scientists
Total Estimated Demand for Nuclear Scientists
Total Estimated Demand for Nuclear Engineers
Total Estimated Supply of Nuclear Engineers
–NUMBER OF NUCLEAR SCIENTISTS AND ENGINEERS–
(Supply data refer only to graduating nuclear scientists and engineers - all levels of degree - from schools which completed the ANS survey questionnaire and which offer degrees and/or courses in nuclear science and engineering. Demand data for nuclear scientists and engineers by government-owned-contractor-operated organizations, national laboratories and defense production facilities contains no growth and only 50% of normal estimated attrition requirements.)

Chart 20

COMPARISON OF THE CURRENT (1969 - 6 MO.) AND ANS PROJECTED (1970-1973) ANNUAL SUPPLY OF GRADUATING NUCLEAR SCIENTISTS AND ENGINEERS WITH BS'S TO THE ANS ESTIMATED ANNUAL DEMAND FOR THESE TYPES BY PRIVATE INDUSTRY, ELECTRIC UTILITIES, EDUCATIONAL INSTITUTIONS AND GOCO FACILITIES.

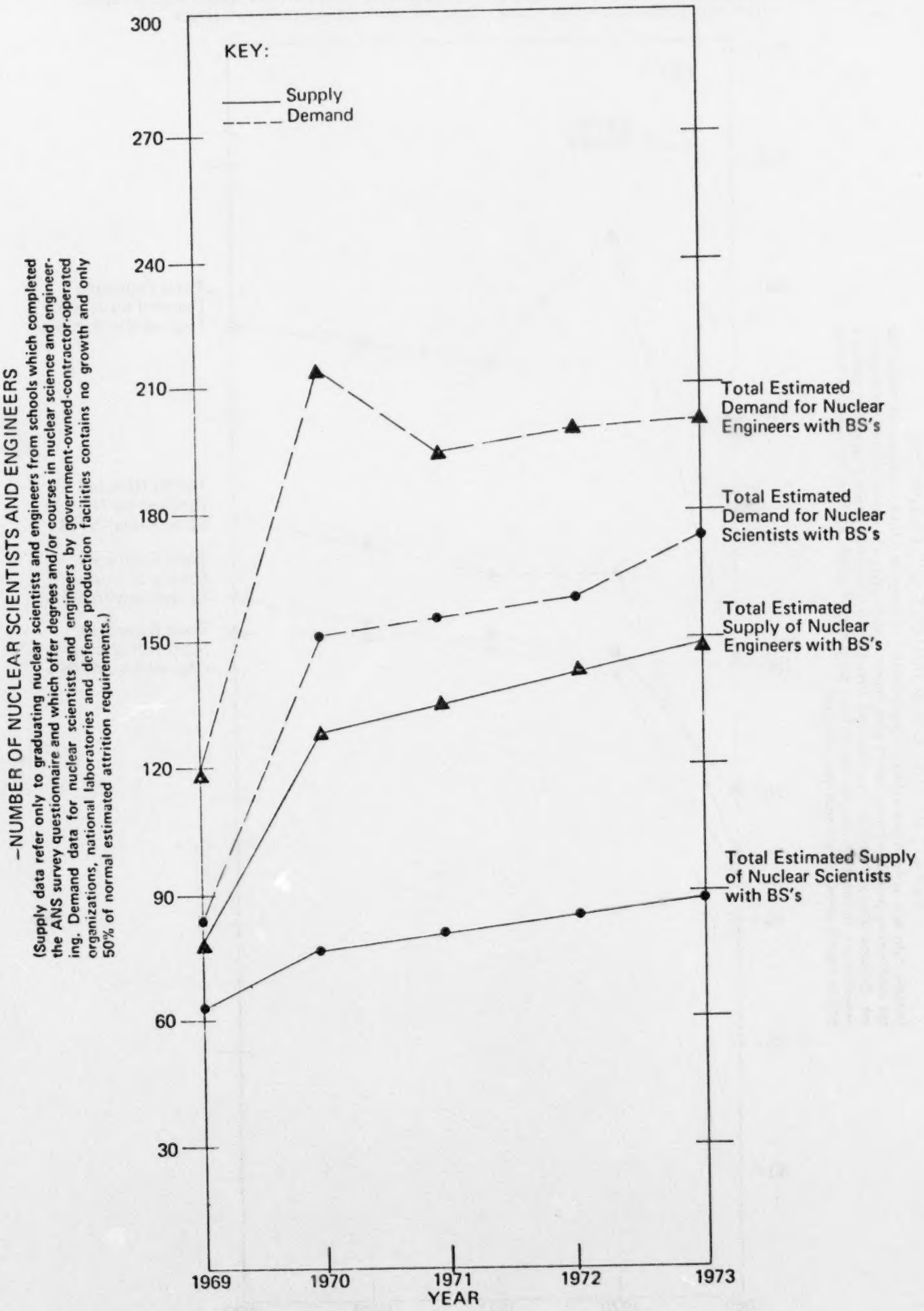

KEY:
Supply
Demand
300
270
240
210
180
150
120
90
60
30
1969
1970
1971
1972
1973
YEAR
–NUMBER OF NUCLEAR SCIENTISTS AND ENGINEERS
(Supply data refer only to graduating nuclear scientists and engineers from schools which completed the ANS survey questionnaire and which offer degrees and/or courses in nuclear science and engineering. Demand data for nuclear scientists and engineers by government-owned-contractor-operated organizations, national laboratories and defense production facilities contains no growth and only 50% of normal estimated attrition requirements.)
Total Estimated Demand for Nuclear Engineers with BS's
Total Estimated Demand for Nuclear Scientists with BS's
Total Estimated Supply of Nuclear Engineers with BS's
Total Estimated Supply of Nuclear Scientists with BS's

Chart 21

COMPARISON OF THE CURRENT (1969 - 6 MO.) AND ANS PROJECTED (1970-1973) ANNUAL SUPPLY OF GRADUATING NUCLEAR SCIENTISTS AND ENGINEERS WITH MS'S TO THE ANS ESTIMATED ANNUAL DEMAND FOR THESE TYPES BY PRIVATE INDUSTRY, ELECTRIC UTILITIES, EDUCATIONAL INSTITUTIONS AND GOCO FACILITIES.

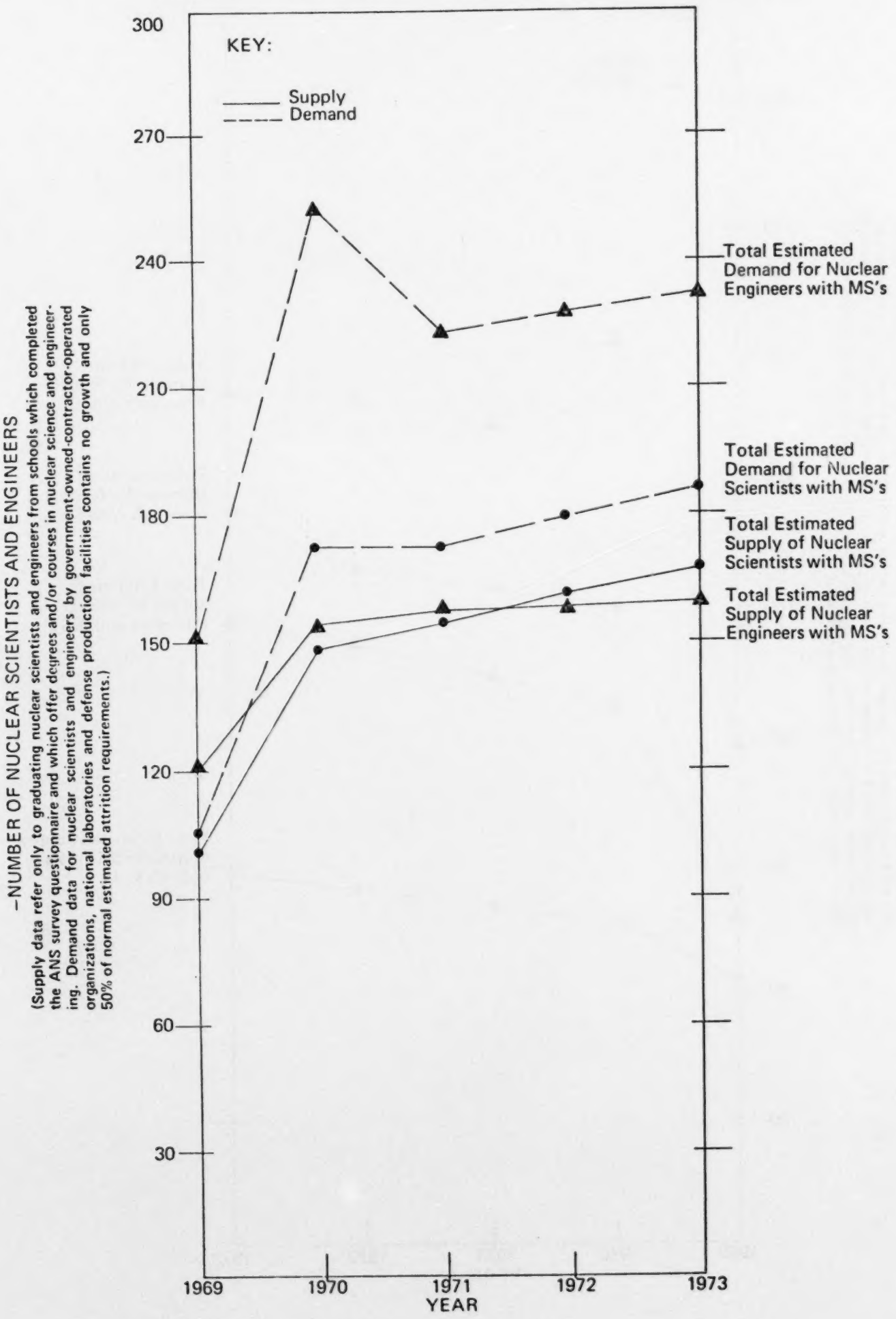
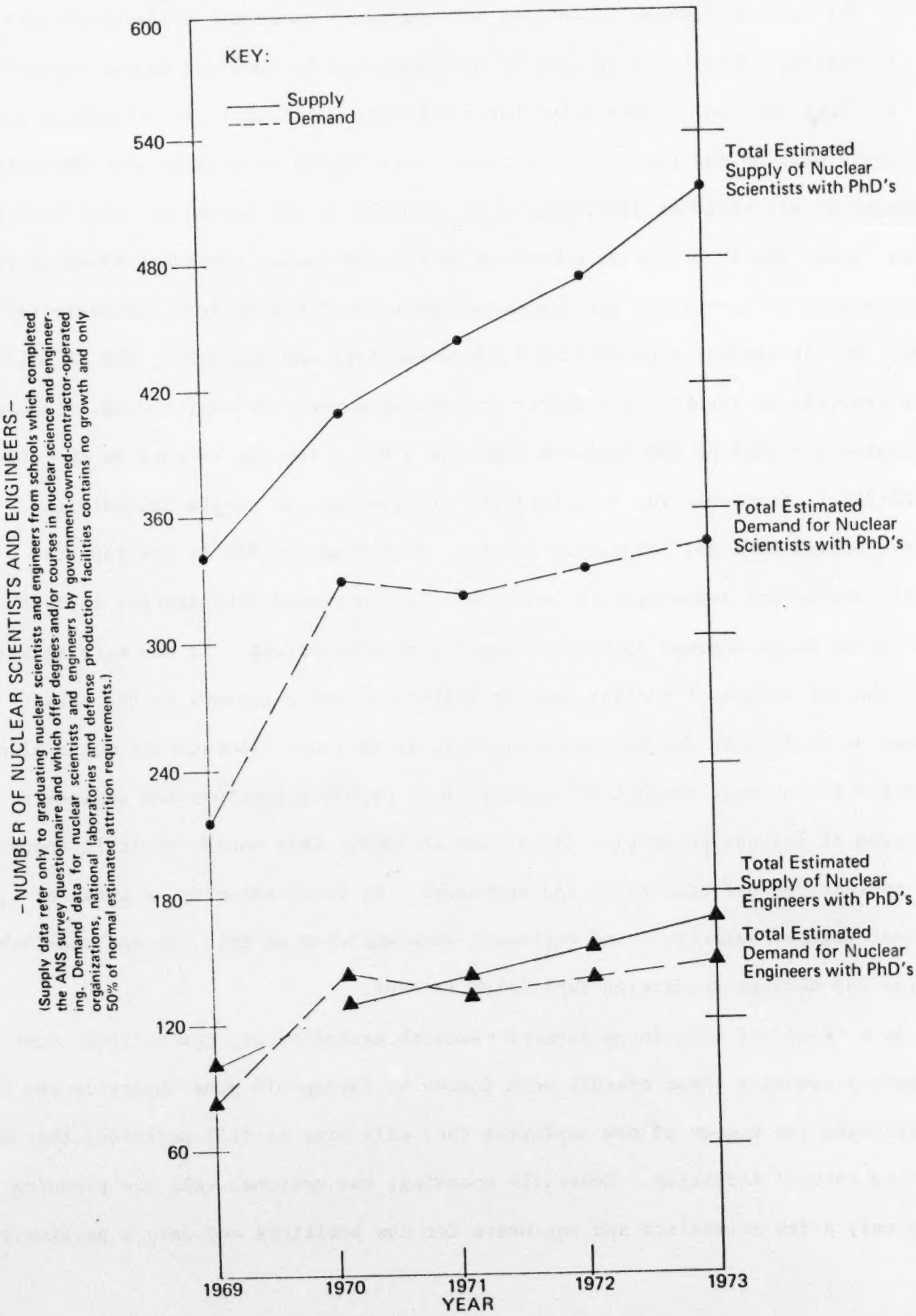

KEY:
Supply
Demand
300
270
240
210
180
150
120
90
60
30
1969
1970
1971
1972
1973
YEAR
Total Estimated Demand for Nuclear Engineers with MS's
Total Estimated Demand for Nuclear Scientists with MS's
Total Estimated Supply of Nuclear Scientists with MS's
Total Estimated Supply of Nuclear Engineers with MS's
–NUMBER OF NUCLEAR SCIENTISTS AND ENGINEERS
(Supply data refer only to graduating nuclear scientists and engineers from schools which completed the ANS survey questionnaire and which offer degrees and/or courses in nuclear science and engineering. Demand data for nuclear scientists and engineers by government-owned-contractor-operated organizations, national laboratories and defense production facilities contains no growth and only 50% of normal estimated attrition requirements.)

Chart 22

COMPARISON OF THE CURRENT (1969 - 6 MO.) AND ANS PROJECTED (1970-1973) ANNUAL SUPPLY OF GRADUATING NUCLEAR SCIENTISTS AND ENGINEERS WITH PhD'S TO THE ANS ESTIMATED ANNUAL DEMAND FOR THESE TYPES BY PRIVATE INDUSTRY, ELECTRIC UTILITIES, EDUCATIONAL INSTITUTIONS AND GOCO FACILITIES.


600
540
480
420
360
300
240
180
120
60
KEY:
Supply
Demand
Total Estimated Supply of Nuclear Scientists with PhD's
Total Estimated Demand for Nuclear Scientists with PhD's
Total Estimated Supply of Nuclear Engineers with PhD's
Total Estimated Demand for Nuclear Engineers with PhD's
1969
1970
1971
1972
1973
YEAR
-NUMBER OF NUCLEAR SCIENTISTS AND ENGINEERS-
(Supply data refer only to graduating nuclear scientists and engineers from schools which completed the ANS survey questionnaire and which offer degrees and/or courses in nuclear science and engineering. Demand data for nuclear scientists and engineers by government-owned-contractor-operated organizations, national laboratories and defense production facilities contains no growth and only 50% of normal estimated attrition requirements.)

EVALUATION OF TOTAL DATA

5) Of the nuclear degreed scientists and engineers currently employed at your laboratory, what is their approximate breakdown by level of degree earned?

The four national laboratories had a combined total of 7,130 scientists and engineers working for them. In 1968 there were 17,125 scientists and engineers employed at all national laboratories as reported by the Bureau of Labor Statistics. Thus, the laboratories contacted in the ANS survey represent 41.6% of the total number of scientists and engineers employed at all national laboratories in 1968. Of the sample laboratories' 7,130 scientists and engineers, 245 (4.8%) have received an identifiable degree in nuclear science or engineering. (Recent estimates provided by AEC indicate that the 4.8% is low and is more on the order of 20-25%.) Extrapolating from the data provided by the sample laboratories to the entire national laboratory complex, approximately 822 of the reported 17,125 scientists and engineers employed at the national laboratories in 1968 had earned their degrees in nuclear science or engineering. If one were to assume that the percentage of nuclear degreed scientists and engineers in the total number of scientists and engineers employed at national laboratories would also hold for the defense production organizations (4,038 scientists and engineers employed at defense production facilities in 1968), this would result in another 194 nuclear degreed scientists and engineers. By this reasoning, a total of 1,016 nuclear degreed scientists and engineers were employed at both the national laboratories and defense production facilities in 1968.

As a result of cuts in government research expenditures, the national labs are presently reducing their overall work forces by laying-off some employees and by restricting the number of new employees they will hire to fill positions that will open by natural attrition. Generally speaking, the national labs are planning to hire only a few scientists and engineers for new positions and only a portion of

those lost through normal attrition. It seems that the labs are following a general principle of replacing these individuals only when a "key" position is involved. It is evident, therefore, that for the next few years the national laboratories will not hire many scientists or engineers and, in particular, will not hire many recent graduates regardless of their educational background. One can assume that what is happening at the national labs is also happening at the other GOCO facilities.

It is necessary to also take into consideration the effect of the layoffs at the national laboratories on the total manpower market in the atomic energy field and especially the effect on graduates in nuclear science and engineering. Employees who are members of the American Nuclear Society who have been laid-off by a national laboratory (there have been many) have found employment elsewhere in the atomic energy field. Obviously, when a prospective employer has the choice between a recent nuclear degreed graduate and someone who has worked at a national laboratory, he will hire the experienced individual. The net result of government cutbacks in research appropriations is the detrimental effect the cutbacks will have on the country's future nuclear capability, both technologically and in terms of skilled manpower resources. The effect of these budget cuts on the graduating nuclear degreed individual's ability to find work for which he is trained can be expected to depress the future enrollments of students in nuclear science and engineering disciplines.

For the present, graduating nuclear degreed students will have to readjust their thinking regarding their method of obtaining work in the atomic energy field. In the next few years there will not be as many research positions available as there have been in the past. The student and his faculty advisor will have to take the initiative for contacting organizations which do not normally recruit

at their campus. There are hundreds of companies (refer to the NUCLEAR NEWS BUYERS GUIDE) active in the atomic energy field which would be receptive to inquires from nuclear degreed graduates. However, the student must want to work for private industry and he will have to convince these companies as to how his educational background in nuclear science or engineering will help the company solve some of its problems.

In interpreting the results of this study, one may come to the conclusion that the educational institutions must reduce their output of nuclear degreed scientists and engineers. However, this approach would certainly be foolhardy when one considers what the long-term effects would be on the atomic energy field. The schools must continue to train people for the nuclear field at about the rate estimated in this study. What the results of the study indicate are that the educational institutions are doing an excellent job in meeting the demands of the atomic energy field for nuclear degreed scientists and engineers. However, the schools should re-evaluate the relative emphasis they place on specific degree levels and disciplines. For example, the universities could stabilize, for the next two or three years, their output of PhD level nuclear scientists and BS level nuclear engineers while increasing their output of MS level nuclear engineers and BS level nuclear scientists. The rate of output of PhD level nuclear engineers should stay about the same as it currently is but the schools might consider an increase productivity of PhD nuclear engineers who have industrial ambitions. By providing the PhD candidates with an opportunity to conduct research on industrial related problems, the student, school and industry will benefit.

The in-depth interviews with selected private companies clearly showed a lack of knowledge on the part of industry in general (excluding, perhaps, the reactor manufacturers and the organizations involved in the design and engineering of nuclear facilities) as to what a nuclear degreed scientist or engineer is trained to do.

If these organizations do not have an appreciation for what a nuclear engineer does, they probably are also unaware of the benefits their company can realize by having a nuclear engineer on their staff. It is suggested, therefore, that the nuclear science and engineering faculty, who are responsible not only for teaching students but also for ensuring their employment, do some missionary work!

DEMAND FOR SCIENTISTS, ENGINEERS AND TECHNICIANS BY SELECTED SEGMENTS OF THE ATOMIC ENERGY FIELD

Table 32 presents the total estimated demand for scientists, engineers and technicians for 1969, 1970, and 1973 only at electric power utilities, educational institutions, and private industry. The increase in manpower requirements, by occupational category, between July 1969 and December 31, 1973 represent the total number of scientists, engineers, and technicians needed to fill new positions at private industry, electric utilities, and educational institutions. Therefore, between July 1969 and December 31, 1973, these 3 sectors of the atomic energy field will grow by 49.3%.

Occupational Categories	% Increase Between July 1969 and Dec. 31, 1973	Numerical Increase Between July 1969 and Dec. 31, 1973
Technicians	58.0%	6,802
Engineers	44.3%	5,130
Scientists	41.5%	2,344
TOTALS	49.3%	14,276

At private industry, electric power utilities and educational institutions, the greatest growth, both numerically and percentagewise, will occur in the technician category. This emphasis on technicians is probably due to three factors: 1) the nuclear industry is shifting its orientation from one of research to product development. In the case of the electric utilities, the majority of their on-site plant personnel are technicians responsible for the operational aspects of running a nuclear power plant; 2) because of the anticipated shortage of engineering

Table 32

CURRENT (1969) EMPLOYMENT OF SCIENTISTS, ENGINEERS AND TECHNICIANS AT PRIVATE INDUSTRY, ELECTRIC POWER UTILITIES AND EDUCATIONAL INSTITUTIONS AND ANS PROJECTIONS OF THEIR MANPOWER REQUIREMENTS FOR THESE TYPES FOR 1970 AND 1973.

(Data include only scientists, engineers and technicians who spend or will spend at least 50% of their working time in atomic energy activities. Data do not include requirements for scientists, engineers and technicians by government-owned-contractor-operated organizations, national laboratories, defense production facilities and federal services.)

OCCUPATIONAL CATEGORIES		CURRENT EMPLOYMENT 6/30/69	1970	INCREASE/ DECREASE	1973	INCREASE/ DECREASE
SCIENTISTS – Life & Physical (Includes Mathematicians)		5,653	6,360	+707	7,997	+1,637
ENGINEERS		11,586	13,442	+1,856	16,716	+3,274
TECHNICIANS	GENERAL TECHNICIANS	11,197	12,885	+1,688	17,171	+4,286
	SENIOR & REACTOR OPERATORS	473	875	+402	1,244	+369
	NUCLEAR MATERIALS MANAGERS	56	76	+20	113	+37
TOTAL ALL TECHNICIANS		11,726	13,836	+2,110	18,528	+4,692
TOTAL SCIENTISTS, ENGINEERS, AND TECHNICIANS		28,965	33,638	+4,673	43,241	+9,603

specialists in the near future, many organizations are planning to hire a greater number of technicians for engineering support functions. This will have the effect of spreading their engineering personnel over a larger number of work activities and will also release the engineers for more profitable endeavors; and, 3) technicians command lower salaries than do professional employees. The companies would be able, therefore, to reduce their operating costs while improving their competitive position.

A breakdown, by level of degree, of scientists and engineers currently employed by private industries, electric power utilities and educational institutions and ANS projections for these professional employees in 1970 and 1973 (not including mathematicians) is presented in Table 33. This Table shows the breakdown of scientists and engineers, by level of degree, for both nuclear degreed scientists and engineers and degreed (non-nuclear) scientists and engineers. The percentage of nuclear degreed individuals with MS's will remain the same during this period of time. However, the percentage of BS level nuclear degreed scientists and engineers will increase by 2.4% between July 1969 and December 31, 1973, while PhD's will decrease by 2.4%. For the other degreed (non-nuclear) scientists and engineers, those with BS's will increase by 0.7% between July 1969 and December 31, 1973; those with MS's will decrease by 0.5%; and, those with PhD's will decrease by 0.2%. These data seem to show a slight decrease, percentagewise, in PhD level personnel, while scientists and engineers with BS degrees will increase. The percentage of scientists and engineers (non-nuclear) with MS's will remain relatively constant during this time period.

Data presented in this report was obtained through survey questionnaires and in-depth interviews. Only three sectors of the nuclear field were covered in the study; namely, educational institutions, electric power utilities, and the private industries active in the atomic energy field. In addition to these three areas,

Table 33

BREAKDOWN OF NUCLEAR-DEGREE AND DEGREE (NON-NUCLEAR) PERSONNEL CURRENTLY (1969) EMPLOYED AND PLANNED FOR IN 1970 AND 1973 BY LEVEL OF DEGREE FOR PRIVATE INDUSTRY, ELECTRIC POWER UTILITIES AND EDUCATIONAL INSTITUTIONS – Data do not include Mathematicians.

(Data include only degree personnel who spend or will spend at least 50% of their working time in atomic energy activities. Data do not include requirements for degree personnel by government-owned-contractor-operated organizations, national laboratories, defense production facilities and federal services.)

CURRENT – 1969

LEVEL OF DEGREE	TOTAL NUCLEAR DEGREED = 4,020	% of TOTAL	TOTAL NON-NUCLEAR DEGREED = 12,650	% of TOTAL
BS	678	16.9%	8,857	70.0%
MS	1,319	32.8%	2,816	22.3%
PhD	2,023	50.3%	977	7.7%

1970

LEVEL OF DEGREE	TOTAL NUCLEAR DEGREED = 4,806	% of TOTAL	TOTAL NON-NUCLEAR DEGREED = 14,821	% of TOTAL
BS	870	18.1%	10,456	70.5%
MS	1,576	32.8%	3,239	21.9%
PhD	2,360	49.1%	1,126	7.6%

1973

LEVEL OF DEGREE	TOTAL NUCLEAR DEGREED = 6,138	% of TOTAL	TOTAL NON-NUCLEAR DEGREED = 18,362	% of TOTAL
BS	1,189	19.3%	12,985	70.7%
MS	2,012	32.8%	3,996	21.8%
PhD	2,937	47.9%	1,381	7.5%

the atomic energy field consists of Commission laboratories, defense production facilities, other GOCO organizations, federal services, and other private and government-owned organizations, such as uranium mining companies and organizations in the construction of nuclear facilities. In an attempt to provide an overall view of the future technical manpower situation in the atomic energy field, the American Nuclear Society (through the use of historical BLS data, evaluations of the growth potentials in the various non surveyed areas of the atomic energy field not covered in the study, etc.) calculated estimates of the total technical manpower requirements of the atomic energy field for 1969, 1970, and 1973. These estimates are presented in Table 34. The reader should view these data as estimates based on historical employment patterns and evaluations of future trends in those areas of the atomic energy field not covered in the study. The data presented in Table 34 for the educational institutions, privately owned establishments and electric power utilities were taken directly from the results of the surveys conducted by the American Nuclear Society.

Undoubtedly, the estimates of technical manpower requirements at the Commission laboratories, defense production facilities, federal services, and all other GOCO organizations for 1970 are, in view of the present budget cuts, optimistic. However, this portion of the study is based on the belief that by 1973 these organizations will be operating "under normal conditions" and, therefore, the ANS expects the estimates for 1973 will be closer to reality than are the 1970 estimates.

If one assumes that these estimates of technical manpower will closely approximate what will happen in the atomic energy field between July 1969 and December 31, 1973, the overall growth in the employment of scientists, engineers and technicians in the atomic energy field between July 1969 and December 31, 1973 will be 30.7%.

Table 34

CURRENT (1969) AND ANS PROJECTED (1970, 1973) REQUIREMENTS FOR SCIENTISTS, ENGINEERS AND TECHNICIANS IN THE ATOMIC ENERGY FIELD.

(Data include requirements for scientists, engineers and technicians by private industry, electric power utilities and educational institutions as determined by the American Nuclear Society's surveys. Also included in the data are estimates made by the ANS and based on historical employment patterns, of requirements for scientists, engineers and technicians by government-owned-contractor-operated organizations, national laboratories, defense production facilities, federal services and other organizations not covered in the ANS study but for which the ANS made estimates.)

SEGMENTS OF THE ATOMIC ENERGY FIELD	CURRENT - 1969				1970				1973			
	TOTALS S,E,& Tech.	Scientists	Engineers	Technicians	TOTALS S,E,& Tech.	Scientists	Engineers	Technicians	TOTALS S,E,& Tech.	Scientists	Engineers	Technicians
Commission Laboratories	29,348	8,926	8,750	11,672	30,735	9,275	9,092	12,368	34,901	10,367	10,162	14,372
Commission Production Facilities	7,251	1,415	2,735	3,101	7,339	1,404	2,738	3,197	7,154	1,335	2,663	3,156
Total Other GOCO	5,809	857	2,390	2,562	5,901	886	2,407	2,608	5,998	892	2,437	2,669
TOTAL GOCO	42,408	11,198	13,875	17,335	43,975	11,565	14,237	18,173	48,053	12,594	15,262	20,197
TOTAL UNIVERSITY RESEARCH AND TEACHING	2,812	1,671	475	666	3,070	1,856	557	657	3,780	2,296	680	804
Uranium Milling	422	79	236	107	465	74	244	147	533	91	282	160
Production of Feed Materials	191	32	77	82	213	23	86	104	295	55	123	117
Production of Special Materials for Use in Reactors	532	91	118	323	617	104	146	367	772	127	164	481
Fuel Element Fabrication and Recovery Activities	1,742	591	408	743	1,923	645	475	803	2,460	881	569	1,010
Reactor and Reactor Design and Manufacturing	9,888	1,404	4,979	3,505	10,883	1,558	5,387	3,938	14,067	1,946	6,814	5,307
Design and Engineering of Nuclear Facilities	4,064	348	1,685	2,031	4,663	370	2,018	2,275	6,024	430	2,374	3,220
Radioactive Waste Disposal	116	–	19	97	154	–	27	127	216	–	39	177
Nuclear Instrument Manufacturing	2,189	223	681	1,285	2,356	254	731	1,371	3,068	327	913	1,828
Processing and Packaging Radioisotopes	495	249	22	224	720	356	44	320	1,042	459	81	502
Particle Accelerator Manufacturing	569	64	164	341	661	67	192	402	836	78	245	513
Private Research Laboratories	3,433	852	1,300	1,281	3,901	968	1,476	1,457	4,596	1,176	1,712	1,708
Industrial Radiography	451	4	53	394	537	4	62	471	652	8	77	567
Miscellaneous	214	16	99	109	261	21	107	133	352	30	142	180
TOTAL PRIVATE ESTABLISHMENTS	24,306	3,953	9,831	10,522	27,354	4,444	10,995	11,915	34,913	5,608	13,535	15,770
TOTAL ELECTRIC POWER UTILITIES	1,847	29	1,280	538(1)	3,214	60	1,890	1,264(1)	4,548	93	2,501	1,954(1)
TOTAL OTHER (2)	13,443	3,952	4,387	5,103	14,977	4,345	4,980	5,652	19,600	5,410	6,890	7,300
GRAND TOTALS	84,816	20,804	29,848	34,164	92,590	22,270	32,659	37,661	110,894	26,001	38,868	46,025

(1) Includes senior reactor operators and reactor operators previously classified as "others".

(2) Includes uranium mining, federal services, defense production facilities, construction of nuclear facilities, other privately owned establishments, etc.

Occupational Categories	% Increase Between July 1969 and Dec. 31, 1973	Numerical Increase Between July 1969 and Dec. 31, 1973
Technicians	34.7%	11,861
Engineers	30.2%	9,020
Scientists	25.0%	5,197
TOTALS	30.7%	26,078

It must be remembered that the estimates are for scientists, engineers, and technicians who will fill new positions.

Allowances for attrition of scientists, engineers, and technicians employed in the atomic energy field in 1969, 1970, and 1973 are given in Table 35. The total number of scientists, engineers, and technicians who could be needed by the atomic energy field between July 1969 and December 31, 1973 to fill new and replacement positions are presented in Table 36. Thus, between July 1969 and December 31, 1973, the requirements of the atomic energy field for scientists, engineers, and technicians to fill new and replacement positions are:

Occupational Categories	Positions	Replacement Positions	Totals
Technicians	11,863	20,289	32,152
Engineers	9,026	12,006	21,032
Scientists	5,201	8,984	14,185
TOTALS	26,090	41,279	67,369

One should not construe these data to mean that these 67,369 scientists, engineers, and technicians will come into the atomic energy field from some other technological field. In fact, through intra-mobility, the majority of the replacement positions will be filled by people already working in the atomic energy field.

The American Nuclear Society estimates that there are over 1,000 organizations participating, to various degrees, in the atomic energy field. These 1,000 organizations include private companies (about 650 U.S. companies listed in the

Table 35

CURRENT (1969) AND ANS PROJECTED (1970, 1973) ALLOWANCES FOR ATTRITION OF SCIENTISTS, ENGINEERS AND TECHNICIANS IN THE ATOMIC ENERGY FIELD.

(Data include allowances for attrition of scientists, engineers and technicians at private industry, electric power utilities and educational institutions based on the data these sectors of the atomic energy field provided to the American Nuclear Society. Also included in the data are allowances for attrition of scientists, engineers and technicians at government-owned-contractor-operated organizations, national laboratories, defense production facilities, federal services and other organizations not covered in the ANS study but for which the ANS made estimates.)

	(Current – 1969 (6 mo.)				1970				1973			
	Total S, E & Tech.	Scientists	Engineers	Tech-nicians	Total S, E & Tech.	Scientists	Engineers	Tech-nicians	Total S, E & Tech.	Scientists	Engineers	Tech-nicians
Annual Employment of Scientists, Engineers & Technicians	84,816	20,804	29,848	34,164	92,590	22,270	32,659	37,661	110,894	26,001	38,868	46,025
Death & Retirement (4%/yr)	1,696	416	597	683	3,704	891	1,306	1,507	4,436	1,040	1,555	1,841
Turnover & Transfers*	1,342	250	238	854	2,939	534	522	1,883	3,548	624	622	2,302
Educational Upgrading while Working (2%/yr)	848	208	298	342	1,852	446	654	752	2,218	520	778	920
TOTAL ALLOWANCE FOR ATTRITION	3,886	874	1,133	1,879	8,495	1,871	2,482	4,142	10,202	2,184	2,955	5,063

*Engineers (1.6%/yr), Scientists (2.4%/yr), Technicians (5%/yr).

Table 36

ANNUAL INCREMENTAL REQUIREMENTS FOR SCIENTISTS, ENGINEERS AND TECHNICIANS WHO WILL SPEND AT LEAST 50% OF THEIR WORKING TIME IN THE ATOMIC ENERGY FIELD: 1969 – 1973.

(Data include annual incremental requirements for scientists, engineers and technicians at private industry, electric power utilities and educational institutions based on the data these sectors of the atomic energy field provided to the American Nuclear Society. Data also include annual incremental requirements for scientists, engineers and technicians by government-owned-contractor-operated organizations, national laboratories, defense production facilities, federal services and other organizations not covered in the ANS study but for which the ANS made estimates.)

SEGEMENTS OF THE ATOMIC ENERGY FIELD	1969 (6 mo.)			1970			1971			1972			1973			TOTAL
	Scientists	Engineers	Technicians	Scientists	Engineers	Technicians	Scientists	Engineers	Technicians	Scientists	Engineers	Technicians	Scientists	Engineers	Technicians	1969-1973
Commission Laboratories	116	114	232	233	228	464	364	356	668	364	357	668	364	357	668	5,553
Commission Production Facilities	(3)	1	32	(8)	2	64	(23)	(25)	(13)	(23)	(25)	(14)	(23)	(25)	(14)	(97)
All Other GOCO	9	5	15	20	12	31	2	10	20	2	10	20	2	10	21	189
TOTAL GOCO	122	120	279	245	242	559	343	341	675	343	342	674	343	342	675	5,645
TOTAL UNIVERSITY RESEARCH AND TEACHING	61	27	(3)	124	55	(6)	146	41	49	147	41	49	147	41	49	968
Uranium Milling	(1)	2	13	(4)	6	27	5	14	4	6	15	4	6	15	5	117
Production of Feed Materials	(3)	3	7	(6)	6	15	10	12	4	11	12	4	11	13	5	104
Production of Special Materials for Use in Reactors	4	9	14	9	18	30	7	6	38	8	6	38	8	6	38	239
Fuel Element Fabrication and Recovery Activities	18	22	20	36	45	40	78	31	69	79	31	69	79	32	69	718
Reactor and Reactor Design and Manufacturing	51	136	144	103	272	289	129	475	456	129	476	456	130	476	457	4179
Design and Engineering of Nuclear Facilities	7	111	81	15	222	163	20	118	315	20	119	315	20	119	315	1960
Radioactive Waste Disposal	–	2	10	–	6	20	–	4	16	–	4	17	–	4	17	100
Nuclear Instrument Manufacturing	10	16	28	21	34	58	24	60	152	24	61	152	25	61	153	879
Processing and Packaging Radioisotopes	35	7	32	72	15	64	34	12	61	34	12	61	35	12	61	547
Particle Accelerator Manufacturing	1	9	20	2	19	41	4	18	37	4	18	37	4	18	37	269
Private Research Laboratories	39	59	59	77	117	117	69	79	84	69	79	84	69	79	84	1,164
Industrial Radiography	–	3	25	–	6	52	2	5	32	3	5	32	3	5	32	205
Miscellaneous	2	6	8	3	12	16	3	11	15	3	12	16	3	12	16	138
TOTAL PRIVATE ESTABLISHMENTS	163	385	461	328	778	932	385	845	1,283	390	850	1,285	393	852	1,289	10,619
TOTAL ELECTRIC POWER UTILITIES	10	203	242	21	407	484	11	203	230	11	204	230	11	204	230	2,701
TOTAL OTHER	130	197	183	262	396	366	355	636	549	355	637	549	355	637	550	6,157
GRAND TOTALS	486	932	1,162	980	1,878	2,335	1,240	2,066	2,786	1,246	2,074	2,787	1,249	2,076	2,793	26,090
ALLOWANCE FOR ATTRITION	874	1,133	1,879	1,871	2,482	4,142	1,975	2,639	4,449	2,080	2,797	4,756	2,184	2,955	5,063	41,279
TOTAL YEARLY REQUIREMENTS FOR SCIENTISTS, ENGINEERS & TECH.	1,360	2,065	3,041	2,851	4,360	6 477	3,215	4,705	7,235	3,326	4,871	7,543	3,433	5,031	7,856	67,369

NUCLEAR NEWS BUYERS GUIDE: 1970), universities that offer courses and/or degree programs in nuclear science and engineering, national laboratories, other GOCO organizations and other establishments (i.e. uranium mining companies, federal services, etc.). Based on these 1,000 organizations, an average company will hire about 15 scientists, engineers and technicians each year to work in its atomic energy activities. Five of these hires will be for new positions and 10 for replacement positions.

APPENDIX A

SURVEY METHODOLOGY AND PROCEDURE

IN-DEPTH INTERVIEW METHOD

The in-depth interview technique was selected as the survey methodology for determining technical manpower requirements of the private industry sector of the atomic energy field. The interview method was selected because it allows for qualitative responses not usually obtained through direct mail questionnaires. Furthermore, it was felt that questionnaires would create an undue burden on industry, and that data obtained from questionnaires may be affected by variations in the interpretation of the questionnaire.

In this study, the in-depth interview technique used was the "standardized" or "structured" interview. Because standardized interviews are designed to collect the same information from each respondent, the answers of all respondents are comparable and classifiable--that is, they deal with precisely the same subject matter. In this study, the subject matter is limited to technical manpower requirements. The differences or similarities between the responses given in the interview reflect the actual differences or similarities between respondents and not differences due to the questions asked or the meanings attributed to the questions.

The in-depth interview consisted of a schedule of 24 sequential questions, developed in advance of the actual interviewing, which were asked of all respondents in exactly the same way and wording. (Refer to APPENDIX B for a list of the in-depth interview questions, directions, and occupational definitions.) Although the in-depth interview was restricted to a series of sequentially predetermined questions, the interview situation was completely "open-end"--the interviewer and respondent were free to enlarge upon the basic questions and answers to further their understanding.

In addition to the 24 questions, each respondent was asked, prior to the

interview, to have on hand for the interview information concerned exclusively with the statistical considerations of his organization's currently employed technical manpower and projections of the company's technical manpower requirements for 1970 and 1973. At the time of the interview, the information was reviewed by the interviewer to help familiarize himself with the technical manpower requirements of the organization being interviewed.

In the development of the in-depth interview technique, the ANS project manager had numerous discussions with individuals and organizations experienced in the use of this technique. Some of the organizations contacted were the National Opinion Research Institute, National Science Foundation, Bureau of Labor Statistics, and the ANS/ASEE Manpower Steering Committee.

The questions were developed and reviewed by ANS, AEC and industrial personnel. The initial questions were revised as a result of these discussions and, after the final set of questions was developed, the ANS project manager conducted a pretest with organizations active in the atomic energy field. Only a few minor changes were made as a result of the pretest experience.

Due to the economic considerations of conducting in-depth interviews, the number of interviews that were to be conducted was limited to a representative sample of the private industry sector of the atomic energy field. The sample was selected by representatives of the American Nuclear Society and the Division of Nuclear Education and Training/U.S. Atomic Energy Commission. The sample selection was based on two considerations: 1) The BLS conducts for the AEC an annual survey of employment in the atomic energy field, by occupation and segment and uses, as a convenient method of defining the atomic energy field, a number of functional categories. For example, in the private industry sector of the atomic energy field, the BLS has identified and defined 14 functional segments such as uranium milling, reactor and reactor component design and

manufacturing, nuclear instrument manufacturing, etc. All organizations responding to the annual BLS survey are categorized into their appropriate functional segment(s) as determined by the organization itself. Organizations interviewed in the ANS survey were chosen from each of the 14 BLS segments. An attempt was made to include small, medium, and large companies in the sample for each segment. It was hoped that the sample companies would represent at least 50% of the total number of technical employees reported in the 1967 BLS "Survey of Employment in the Atomic Energy Field by Occupation and Segment."

The actual in-depth interviews were conducted by the senior staff members of the American Nuclear Society. The procedure followed in scheduling an interview was to contact an ANS member at the selected company and request that he provide the name of the individual(s) most knowledgeable of his organization's technical manpower. The individual recommended by the ANS member was then contacted by telephone, the purpose of the survey was explained and, if the organization was willing to participate, a tentative appointment was made for conducting the interview. (Only 2 out of the total sample of 70 companies declined to participate.) A letter was then sent to the respondent to confirm the appointment and a request was made that data on their technical manpower requirements be available for the interview. At no time prior to the interview was the respondent made aware of specific questions that would be asked during the interview.

A typical interview lasted about 1 hour and, in most instances, 2 or more individuals from the company participated in the interview. The majority of the interviews were conducted with representatives of the organization's executive office, personnel department and, most importantly, with the Heads of the research and/or engineering departments.

The interviews were conducted during the period extending from March through

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August 1969. A total of 68 organizations were interviewed.

Projections of the technical manpower requirements of the sample organizations were extrapolated to cover all of the selected segments of the private sector of the atomic energy field included in the survey. For each functional segment (i.e., uranium milling), extrapolations were based on a weighed average of the percentage of the total technical manpower of the sample companies to the total technical manpower reported by the BLS in each functional segment for the years 1966, 1967, and 1968.

ELECTRIC POWER UTILITY SURVEY

This study was conducted by Dr. A. David Rossin, Argonne National Laboratory and Keith L. Voigt, American Nuclear Society under the co-sponsorship of the ANS Power Division and the Reactor Operation Division. The purpose of the study was to assess the future requirements of the electric utility industry for degreed (non-nuclear), nuclear degreed, and nuclear trained (non-degreed) personnel.

The data were collected through the use of direct mail questionnaires. An advisory committee, composed of representatives of the sponsoring ANS Divisions, reviewed the progress of the study.

The preliminary questionnaire was developed after numerous consultations with representatives of the utility industry and the Edison Electric Institute. The initial draft questionnaire was reviewed by the ANS advisory committee and was then pretested with a number of electric utilities. A few minor changes were made as a result of the pretest experience and the final questionnaire, its directions, and cover letter were mailed to 46 U.S. electric utilities during the week of February 3, 1969. (Refer to APPENDIX C for a sample of the questionnaire and directions.) Only those electric utilities that had or were planning to have nuclear power plants in operation by 1976 were contacted. A follow-up letter which requested the company to complete the questionnaire was mailed to the non-

respondents on April 11, 1969.

To reduce variations in the interpretation of the questionnaire between participating utilities, the directions included the names, addresses and telephone numbers of the advisory committee members. The electric utilities were urged to contact any of these individuals if they had any questions regarding their interpretation of the questionnaire or the procedure for completing the questionnaire.

The results were extrapolated to the entire U.S. electric utility manpower requirements, based on published information concerning the power ratings and time schedules for unreported plants.

Data given in the section of this report titled "Technical Manpower Requirements of the Electric Utilities" have been updated from the data published by Rossin and Voigt to take into account the additional nuclear power plants recently announced and the cancellation of a previously annouced nuclear power plant.

COLLEGE-UNIVERSITY SURVEY

The purpose of this study was to determine the future requirements of the educational institutions for full and part-time faculty, research and development, and nuclear facilities personnel. In addition, the study attempted to assess the extent of student enrollments in stipulated nuclear science and engineering disciplines by level of degree for 1969, 1970, and 1973.

Data were collected through the use of direct mail questionnaires. The development of the questionnaire was accomplished through numerous discussions with university, professional, and educational association representatives. The draft questionnaire was pretested with a number of universities and their recommended changes were incorporated in the questionnaire. (Refer to APPENDIX D for a sample of the questionnaire.)

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For purposes of the study, the survey universe was defined as those schools which appeared in the 1966 edition of "Educational Programs and Facilities in Nuclear Science and Engineering." On December 8, 1967, the questionnaire was sent to a total of 269 colleges and universities. A follow-up letter was mailed January 24, 1968.

Because the university survey was to be incorporated in the overall ANS survey of technical manpower requirements and, because the other elements of the overall survey; namely, the in-depth interview with private industries and the electric power utility survey were delayed in their completion, an updated survey of the educational institutions was undertaken. The updated survey covered a sample of 25 schools which had participated in the first university survey. These sample universities were also sent a copy of the questionnaire they had completed in the initial survey. They were asked to review their previous estimates in light of the current situation at their school, and to update their estimates if they felt their first estimates were no longer representative. The updated survey was conducted during July and August 1969.

The updated survey data provided by the sample schools were extrapolated to the study's entire educational institution universe to account for changes in requirements for faculty, research and development and nuclear facilities personnel, and nuclear science and engineering student enrollments that had occured between December 1967 and July 1969.

As has been previously stated, the primary purpose of the entire ANS/AEC study was to establish a supply/demand ratio for nuclear degreed scientists and engineers. However, more than just information on student enrollments was necessary to develop a meaningful estimate of the potential supply. To determine how many students currently enrolled and planned for enrollment in 1970 and 1973 would actually be available each year for employment in the U.S. atomic energy field, the American Nuclear Society conducted a telephone survey during the week

of February 2, 1970. Eighteen major nuclear science and engineering degree granting universities were contacted.

The telephone survey consisted of the same four questions for each level of degree and the data requested was limited to the 1968-69' academic year. The questions asked were:

1. How many students were enrolled in coursework leading to a degree in nuclear science or engineering?
2. How many students were conferred degrees in nuclear science or engineering?
3. How many or what percentage of students who received a degree in nuclear science or engineering, enrolled in coursework leading to an advanced degree in nuclear science or engineering, or to post-graduate work?
4. Approximately how many or what percentage of the graduating students in nuclear science or engineering were drafted or voluntarily joined the military service.

In order to determine how many MS and PhD graduates in nuclear science or engineering were foreign students who would return to their home country or to a country other than the U.S., the results of Dr. A. David Rossin's study of "Foreign Student Obtaining MS and PhD Degrees at American Universities (1952-1967)" were used. These data were used to establish realistic estimates of graduating nuclear science and engineering students who would be available each year for employment in the U.S. atomic energy field.

APPENDIX B

NUCLEAR MANPOWER SURVEY

TITLE

Survey of Employment Requirements by the Private Industry and Electric Utility Sectors of the Atomic Energy Field for Scientists, Engineers, Mathematicians, Technicians, Senior and Reactor Operators, and Nuclear Materials Managers Who Spend At Least 50% of Their Working Time in Atomic Energy Activities.

INTRODUCTION

In order for the nation's educational community to prepare itself to meet the future manpower needs of private industry and electric utilities active in the atomic energy field, the educational institutions must be provided with authoritative statistical data which qualifies and quantifies the demand for nuclear trained scientists, engineers, technicians, senior and reactor operators, and nuclear materials managers. Such data would help to strengthen current educational endeavors and would also help to support new educational endeavors in the field of nuclear science and engineering. Furthermore, these data could help to direct government support to those areas where the needs are most evident. A final report of the survey results could also be utilized by companies and utilities in planning their future manpower requirements.

CONDUCTING ORGANIZATION

The survey is being conducted by the American Nuclear Society.

SPONSORING ORGANIZATION

The survey is sponsored by the Division of Nuclear Education and Training/U.S. Atomic Energy Commission.

PROPRIETARY INFORMATION

All data and information obtained in the interview will be strictly confidential. Statistics of individual companies or utilities <u>will not be released</u>.

AMERICAN NUCLEAR SOCIETY
SPECIAL PROJECTS DEPARTMENT

Nuclear Manpower Survey

Name and Address of Interviewed Organization

(A) _____

_____

_____
(ZIP CODE)

Telephone Number _____
(AREA CODE)

Name and Address of Organization's Other Subsidiaries and/or Divisions Which Also Participate in the Atomic Energy Field:

(B) _____

_____

_____
(ZIP CODE)

(C) _____

_____

_____
(ZIP CODE)

(D) _____

_____

_____
(ZIP CODE)

(E) _____

_____

_____
(ZIP CODE)

.ame of the Respondent(s):

Name _____ Title _____

Name _____ Title _____

Date of the Interview _____
(DAY) (MONTH) (YEAR)

Interviewed By _____
(SIGNATURE)

Would you please indicate the segment(s) of the atomic energy field your organization and its subsidiaries and/or divisions participate in?

- ☐ URANIUM MILLING
- ☐ PRODUCTION OF FEED MATERIALS
- ☐ PRODUCTION OF SPECIAL MATERIALS FOR USE IN REACTORS
- ☐ FUEL ELEMENT FABRICATION AND RECOVERY ACTIVITIES
- ☐ REACTOR AND REACTOR COMPONENT DESIGN AND MANUFACTURING
- ☐ DESIGN AND ENGINEERING OF NUCLEAR FACILITIES
- ☐ POWER REACTOR OPERATION AND MAINTENANCE
- ☐ RADIOACTIVE WASTE DISPOSAL
- ☐ NUCLEAR INSTRUMENT MANUFACTURING
- ☐ PROCESSING AND PACKAGING RADIO-ISOTOPES
- ☐ PARTICLE ACCELERATOR MANUFACTURING
- ☐ PRIVATE RESEARCH LABORATORIES
- ☐ INDUSTRIAL RADIOGRAPHY
- ☐ MISCELLANEOUS

AMERICAN NUCLEAR SOCIETY
SPECIAL PROJECTS DEPARTMENT

Nuclear Manpower Survey

Name and Address of Interviewed Utility

_____

_____

_____
(ZIP CODE)

Telephone Number _____
(AREA CODE)

Name of Nuclear Plant(s)

	(1)	(2)
Name	_____	_____
Type of Reactor (BWR, PWR, etc.)	_____	_____
Megawatts$_e$	_____	_____
Start of Construction (Date)	_____	_____
Operating Personnel on Site (Date)	_____	_____
Commercial Operation (Date)	_____	_____
Reactor Manufacturer	_____	_____

	(3)	(4)
Name	_____	_____
Type of Reactor (BWR, PWR, etc.)	_____	_____
Megawatts$_e$	_____	_____
Start of Construction (Date)	_____	_____
Operating Personnel on Site (Date)	_____	_____
Commercial Operation (Date)	_____	_____
Reactor Manufacturer	_____	_____

Name of Respondent(s)

Name _____ Title _____

Name _____ Title _____

Date of Interview _____
(DAY) (MONTH) (YEAR)

Interviewed By _____
(SIGNATURE)

INTERVIEW QUESTIONS

CURRENT EMPLOYMENT

(Include only those employees who spend at least 50% of their working time in your organization's atomic energy activities.)

Question 1 -- Using the May 1968 employment data reported by you to the U.S. Department of Labor, Bureau of Labor Statistics, how many physical scientists, life scientists, and engineers have received degrees in nuclear science or engineering?

Question 2 -- Would you indicate the educational backgrounds of the nuclear degreed and degreed (non-nuclear) scientists and engineers currently employed by your organization?

Question 3 -- Of the total number of nuclear degreed and degreed (non-nuclear) scientists and engineers currently employed by your organization, how many have PhD's, MS's or BS's?

Question 4 -- What is the first (primary) qualification your company considers when hiring scientists, engineers, technicians, senior and reactor operators, and nuclear materials managers?

Question 5 -- Does this qualification(s) also prevail when you are hiring a scientist or engineer with a nuclear degree?

Question 6 -- In what company activities do the majority of your nuclear degreed scientists and engineers, degreed (non-nuclear) scientists and engineers, technicians, senior and reactor operators, and nuclear materials managers work?

Question 7 -- Is your company's current staffing needs for nuclear degreed scientists and engineers filled?

Question 8 -- During the past 5 years (1963-1968), what degree of success has your company experienced in filling its needs for nuclear degreed scientists and engineers, degreed (non-nuclear) scientists and engineers, technicians, senior and reactor operators, and nuclear materials managers?

Question 9 -- During the past 5 years (1963-1968), has your company increased or decreased its need for nuclear degreed scientists and engineers?

Question 10 - Would you briefly discuss some of the reasons why your company hires degreed (non-nuclear) scientists and engineers for positions in your company's atomic energy activities.

Question 11 - Does your company believe that the degreed (non-nuclear) scientists and engineers would be more valuable if they had some coursework in nuclear science or technology?

Question 12 - How does the education received by the nuclear degreed scientists and engineers match the responsibilities they have in your organization? (i.e., How relavant is their educational background in nuclear science or engineering in relation to your company's particular technical environment?)

INTERVIEW QUESTIONS

Question 13 - Of the total number of employees currently employed in your company's atomic energy activities, approximately how many of these employees do not have an academic degree in science or engineering, but through experience or training are able to assume job responsibilities equivalent to those of a degreed scientist or engineer?

FUTURE EMPLOYMENT

Question 1 -- What extrinsic and intrinsic factors did you use in making your employment estimates for 1970 and 1973?

Question 2 -- Of the factos indicated in question 1, which extrinsic and intrinsic factor has proved to be the most reliable (most accurate) measure of your company's technical manpower needs?

Question 3 -- Assume that government funds to your company were to decrease by 10% of their current level in 1970 or 1973. Would your 1970 or 1973 employment estimates for nuclear degreed, degreed (non-nuclear) scientists and engineers, technicians, senior and reactor operators, and nuclear materials managers increase? decrease? or remain unchanged?

Question 4 -- By 1970 or 1973, do you anticipate any change in your company's emphasis on hiring degreed (non-nuclear) scientists and engineers with a particular educational background as compared to its current hiring practices? For example, a greater emphasis on hiring electrical engineers rather than the company's current emphasis on hiring mechanical engineers.

Question 5 -- Do you expect the supply of nuclear degreed scientists and engineers to be large enough to meet the manpower requirements of your company in 1970 and 1973.

Question 6 -- What role should a company such as your company play in financing and/or developing educational programs to meet this growing need for nuclear degreed scientists and engineers?

Question 7 -- Do you expect the growth in your company's area of the nuclear field to plateau within the next 10 years or will it continue to grow at the present rate?

EMPLOYEE TRAINING PROGRAMS

Question 1 -- Does your company require its employees to take additional nuclear science or technology courses beyond their formal education?

Question 2 -- Are these additional courses and/or training programs in nuclear science or technology conducted: a. through an "in-house" training program? b. in association with a college or university? c. in association with a technical school, trade school, etc.? d. by a vendor? e. in association with a consulting organization? or, f. other source? (specify).

Question 3 -- Would you indicate the various types of courses in nuclear science and technology currently being taken by your employees or that your company would like them to take?

UNIVERSITY & COLLEGE TRAINING PROGRAMS

Question 1 -- In your opinion, are there any specialties for which particular courses or graduate study or curricula are not offered in nuclear science and engineering, but for which your company feels training should be offered?

ATTACHMENT I
Occupational Definitions

PHYSICAL SCIENTISTS -- Count as physical scientists all chemists, physicists, metallurgists, geologists, geophysicists, and other physical and earth scientists who are actually engaged in scientific work at a level which requires a knowledge of the physical sciences equivalent to that acquired through completion of a 4-year college course with a major in one of the physical science fields, regardless of whether they hold a college degree. Include all physical scientists engaged in research and development, production management, technical service, sales, and other positions which require them to use the indicated level of knowledge in their work. Exclude persons trained in the physical sciences but currently employed in positions not requiring the use of such training.

LIFE SCIENTISTS -- Count as life scientists all health physicists (see definition below), medical scientists, agricultural scientists, biological scientists, and other life scientists who are actually engaged in scientific work at a level which requires a knowledge of the life sciences equivalent to that acquired through completion of a 4-year college course with a major in one of the life science fields, regardless of whether they hold a college degree. Include all life scientists engaged in research and development, production, management, technical service, sales, and other positions which require them to use the indicated level of knowledge in their work. Exclude persons trained in the life science but currently employed in positions not requiring the use of such training.

ENGINEERS -- Count as engineers all persons actually engaged in engineering work at a level which requires knowledge of engineering equivalent at least to that acquired through completion of a 4-year college course with a major in one of these fields, regardless of whether they hold a college degree. Include all engineers in research and development, production, management, technical service, sales, and other positions which require them to use the indicated level of knowledge in their work. Exclude persons trained in engineering but currently employed in positions not requiring the use of such training. Include architectural engineers. Exclude architects and nuclear reactor operators.

MATHEMATICIANS -- Count as mathematicians only those persons whose position require a knowledge of mathematics equivalent at least to that acquired through a 4-year college course with a major in mathematics and who spend the greatest proportion of their time in development or application of mathematical techniques, regardless of whether they hold a college degree. Include all mathematicians in research and development, production, management, technical service, sales, and other positions which require them to use the indicated level of knowledge in their work. Include actuaries, statisticians, and computer programmers only if they specialize in mathematical techniques. Exclude accountants.

TECHNICIANS -- Count as technicians all persons actually engaged in technical work at a level which requires knowledge of engineering, mathematical, and physical and life sciences, comparable to that acquired either through study at technical institutes, junior colleges, or other formal post-high school training less extensive than a 4-year college course, or through equivalent on-the-job training or experience. Some typical job titles are draftsmen, electrical and electronics technicians, engineering technicians, health physics technicians and radiation monitors, life science technicians, etc. All persons in positions which require the indicated level of knowledge should be counted, regardless of job title or department in which employed. Computer programmers who meet the above definition of technicians should be reported as "Other Technicians." Exclude nuclear reactor operators and all craftsmen such as machinists and electricians.

NUCLEAR REACTOR OPERATORS -- Count as nuclear reactor operators all persons who spend the greatest proportion of their time either in (a) the actual manipulation of the controls of a nuclear reactor, or (b) directing others in the manipulation of such controls. Under AEC licensing regulations, the former are referred to as "operators" and the latter as "senior operators." Exclude persons who spend the greatest proportion of their time as nuclear reactor engineers or in performing other functions of a professional, scientific or engineering nature.

HEALTH PHYSICISTS -- Count as health physicists all persons who meet the general requirements for "Life Scientists or Engineers" and who are concerned with programs to protect plant and laboratory personnel from radiation hazards; develop inspection standards, radiation exposure limits, and decontamination procedures; conduct tests to insure that radiation is not in excess of permissible limits; and design or modify such health physics equipment as detectors and counters to improve radiation protection. Include all health physicists in the category titled "Life Scientists."

NUCLEAR MATERIALS MANAGER -- Count as nuclear materials managers those persons who are concerned with the effective use of methods, procedures, and techniques for recording, reporting, analyzing, evaluating, adjusting, and regulating nuclear materials inventories to assure maximum efficiency and economy consistent with established national and corporate policies and goals. More specifically, nuclear materials management includes acquisition, use and disposal of materials so as to effect maximum economies in materials utilization and to minimize consumption and losses; development and maintenance of records, measurement and physical inventory procedures to provide quantity data for cost and financial control, production control, and health and safety; establishment of internal controls to guard against carelessness, theft and misappropriation and to assure compliance with managerial policy; determination of economic inventory levels and reorder quantities consistent with program requirements; and, determination of the economies of current recovery of scrap vis-a-vis storage for future recovery or discard.

APPENDIX C

NUCLEAR TRAINED MANPOWER NEEDS IN ELECTRIC POWER INDUSTRY

This survey is being co-sponsored by the Power Division and Reactor Operations Division of the American Nuclear Society under the direction of Dr. A. David Rossin. Completed questionnaires should be returned to the American Nuclear Society, 244 East Ogden Avenue, Hinsdale, Illinois 60521. An addressed, post-paid envelope is enclosed for your convenience.

Enter the name and address of your company.

_____

_____

_____

_____
(Zip Code)

Name _____ Title _____
(Person to Contact for Further Information)

I. Enter the following information in the space provided. Include only nuclear plant(s) now in operation or planned for operation by December 31, 1976.

Name of Nuclear Plant(s)	Type of Reactor (BWR, PWR, etc.)	Megawatts$_e$	Start of Construction (Date)	Operating Personnel on Site (Date)	Commercial Operation (Date)
1.					
2.					
3.					
4.					
5.					

I-SITE" NUCLEAR PLANT PERSONNEL

er the total number of "on-site" plant personnel currently employed by your organization by area of activity, function and highest level of degree. Enter a reasonable estimate of the total number of "on-site" plant personnel your organization plans to employ in 1970 and 1973 by area of activity, function and desired level of degree. Enter only those "on-site" plant personnel who have had some nuclear training.

A. GENERAL AND OPERATIONS

FUNCTION	CURRENTLY EMPLOYED – 12/68					PLANNED 1970					PLANNED 1973				
	PhD	MS	BS	Tech.	Other	PhD	MS	BS	Tech.	Other	PhD	MS	BS	Tech.	Other
General Plant Superintendents and Assistants															
Operations Superintendents and Assistants (not normally on shift)															
Operations Shift Supervisors and Assistants															
Operations Supervisors and Assistants															
Senior Reactor Operators															
Reactor Operators															
Equipment Operators															
Fuel Handlers (if a special group and not part of the above)															
Others															

B. MAINTENANCE (Normal Plant Complement)

Maintenance Superintendents and Assistants															
Mechanical Maintenance Supervisors and Assistants															
·cal Maintenance Supervisors ssistants															
a. anics and Apprentices															
Electricians and Apprentices															
Others															

C. TECHNICAL SERVICES

FUNCTION	CURRENTLY EMPLOYED – 12/68					PLANNED 1970					PLANNED 1973				
	PhD	MS	BS	Tech.	Other	PhD	MS	BS	Tech.	Other	PhD	MS	BS	Tech.	Other
Engineering Superintendents and Assistants															
Technology (Engineers):															
Reactor or Nuclear Engineers															
Radiation Protection – Health Physicists															
Chemists – Chemical Engineers															
Instrument/Control and Computer Engineers															
General Engineers															
Technology (Technicians):															
Reactor or Nuclear Engineering Technicians															
Radiation Protection – Health Physics Technicians															
Chemical Engineering Technicians															
Instrument/Control Technicians															
General Technicians															
Others															

III. "OFF-SITE" OR CENTRAL OFFICE PERSONNEL

Enter the total number of "off-site" or headquarters' office personnel currently employed by your organization by area of activity, function and highest level of degree. Enter a reasonable estimate of the total number of "off-site" or headquarters' office personnel your organization plans to employ in 1970 and 1973 by area of activity, function and desired level of degree. Enter only those "off-site" personnel who have had some nuclear training.

A. DESIGN AND SAFETY ANALYSIS (Do Not Include Private Consultants, A/E's, etc.)

FUNCTION	CURRENTLY EMPLOYED – 12/68					PLANNED 1970					PLANNED 1973				
	PhD	MS	BS	Tech.	Other	PhD	MS	BS	Tech.	Other	PhD	MS	BS	Tech.	Other
Engineering Supervisors and Assistants															
Mechanical Engineers															
Structural Engineers															
Electrical Engineers															
Hydraulic Engineers															
Nuclear Engineers															
Metallurgical Engineers															
Architectural Engineers															
Civil Engineers															
Safety Analysis Engineers															
Instrument and Instrument Control Engineers															
Nuclear Licensing Administrators															
Designers and Draftsmen															
Engineering Technicians															
Others															

B. RESEARCH AND DEVELOPMENT

FUNCTION	CURRENTLY EMPLOYED – 12/68					PLANNED 1970					PLANNED 1973				
	PhD	MS	BS	Tech.	Other	PhD	MS	BS	Tech.	Other	PhD	MS	BS	Tech.	Other
Physicists															
Chemists – Chemical Engineers															
Electrical Engineers															
Mechanical Engineers															
Metallurgical Engineers															
Materials Engineers															
Health Physicists															
Safety Engineers															
Engineering Technicians															
Others															

C. CONSTRUCTION

Construction Superintendents and Assistants															
Project Supervisors															
Site Representatives															
Assurance Engineers															
ngineers															
Construction Technicians															
Others															

D. OPERATIONS AND FUEL CYCLE MANAGEMENT

Nuclear Engineers															
Chemical Engineers															
Materials Engineers															
Metallurgical Engineers															
Mechanical Engineers															
Physicists															
Mathematicians															
Purchasing Agents															
Accountants															
Accountability Clerks															
Technicians and Draftsmen															
Others															

E. PERIODIC MAINTENANCE (refers to "rotating" maintenance crews not permanently assigned to one specific plant)

FUNCTION	CURRENTLY EMPLOYED – 12/68					PLANNED 1970					PLANNED 1973				
	PhD	MS	BS	Tech.	Other	PhD	MS	BS	Tech.	Other	PhD	MS	BS	Tech.	Other
Maintenance Superintendents and Assistants															
Mechanical Maintenance Supervisors and Assistants															
Electrical Maintenance Supervisors and Assistants															
Mechanics and Apprentices															
Electricians and Apprentices															
Others															

F. ADMINISTRATION (includes corporate officers, legal, financial, purchasing, public relations, and industrial relations personnel)

Administrators															
Others															

IV. TRAINING PROGRAMS

Indicate by checking (✓) the appropriate box the type of training program(s) by area of activity your organization is currently utilizing. Indicate the type of training program(s) by area of activity your organization plans to use in 1970 and 1973.

Types of Training Programs	CURRENTLY EMPLOYED – Areas of Activity										PLANNED 1970 – Areas of Activity										PLANNED 1973 – Areas of Activity									
	General & Operations	Maintenance	Technical Services	Design & Safety Analysis	Research & Development	Construction	Operations & Fuel Cycle Mgt.	Periodic Maintenance	Administrative		General & Operations	Maintenance	Technical Services	Design & Safety Analysis	Research & Development	Construction	Operations & Fuel Cycle Mgt.	Periodic Maintenance	Administrative		General & Operations	Maintenance	Technical Services	Design & Safety Analysis	Research & Development	Construction	Operations & Fuel Cycle Mgt	Periodic Maintenance	Administrative	
At a technical school.																														
At a university or college.																														
At an AEC facility.																														
"On-the-job" training at a conventional power plant.																														
An "in-house" formal lecture type training program.																														
"In-house" training using a simulator.																														
Vendor's training program.																														
"On-the-job" training at your utility's nuclear plant.																														
Training conducted by a consulting firm.																														
"On-the-job" training at another utility's nuclear plant.																														
No formal training program-will hire experienced personnel.																														
Other (please specify below).																														

Other:

GENERAL DIRECTIONS

1. Please review the entire questionnaire to acquaint yourself with the general format.

2. In preparing the questionnaire, general classifications of personnel have been used in the "Function" column. It is realized that the job titles may not agree with those used by your utility, but it is felt that after reviewing the questionnaire you will be able to fit each employee into one of the classifications.

3. The questionnaire applies only to those employees who have had some nuclear training. In general, the employee should have successfully completed a training program which the utility feels is adequate for the work which the employee will be doing. More specific examples of "some nuclear training" are given below as guidelines:

   a. For headquarters personnel -- a training program, whether given at a local school or conducted "in-house," that is equivalent to a graduate level course in reactor engineering, would qualify a person as being nuclear trained.
   b. For maintenance personnel -- a short course in health physics radiation protection would suffice to train the employee for the work which he will do.
   c. For operations personnel -- "on-site" programs covering an introduction to nuclear theory and a description of reactor systems would be sufficient to be considered nuclear training.

4. Time periods are CURRENTLY EMPLOYED, PLANNED 1970, and PLANNED 1973. The reference month is December for each of these time periods.

5. Data entered in each of the time periods represents the total number of employees you expect to have on your payroll as of that date.

6. Account for each employee only once in each time period.

7. For those employees who have an AEC senior reactor operator or reactor operator license but are not operating a reactor, enter them in the function for which they are employed. For example, a licensed operator employed as a plant superintendent should be entered as a plant superintendent.

8. Tech. refers to technician.

9. This study will be most effective if completed and returned by March 31, 1969. Consequently, your prompt reply will be appreciated.

10. If you have any questions concerning the completion of the questionnaire, please feel free to contact any one of the following members of the survey's steering committee:

    a. Mr. Vincent S. Boyer
    Philadelphia Electric Co.
    1000 Chestnut St.
    Philadelphia, Pa. 19105
    215/WA 2-4700

    b. Mr. Edward C. Fiss
    Duke Power Co.
    P.O. Box 2178
    Charlotte, N.C. 28201
    704/332-8521

    c. Mr. Edward C. Pandorf
    Cincinnati Gas & Electric Co.
    P.O. Box 960 -- Room 512
    Cincinnati, Ohio 45201
    513/632-2753

    d. Mr. A. David Rossin
    Bldg. #10 -- Argonne Nat'l Laboratory
    Argonne, Ill. 60439
    312/739-7711 Ext. 4124

    e. Mr. Louis J. Weidner, Jr.
    Dept. of Water & Power of the City of Los Angeles
    357 S. Hill St.--Room 1115--Black Bldg.
    Los Angeles, Cal. 90013
    213/481-5411

    f. Mr. Keith L. Voigt
    American Nuclear Society
    244 E. Ogden Avenue
    Hinsdale, Ill. 60521
    312/325-1991 Ext. 32

APPENDIX D

SURVEY OF TECHNICAL MANPOWER REQUIREMENTS IN UNIVERSITIES IN ATOMIC ENERGY ACTIVITIES

Conducted by the American Nuclear Society and the American Society of Engineering Education
for the Atomic Energy Commission's Division of Nuclear Education and Training

Please Enter Name and Address of Institution.

_____

_____

_____ (ZIP CODE)

2. TEACHING – FULL TIME
Please Enter Number of Faculty Employed and Planned for Teaching in the Nuclear Field.

DISCIPLINE	Currently Employed			Planned 1970			Planned 1973		
	PhD	MS	BS	PhD	MS	BS	PhD	MS	BS
Nuclear Physics									
Thermonuclear Physics									
High Energy Physics									
Nuclear and Radiation Chemistry									
Reactor Engineering									
Other Nuclear Engineering									
Radiation Applications									
Health Physics									
Radiation Biology									

2A. TEACHING – PART TIME
Please Enter Number of Faculty Employed and Planned for Teaching in the Nuclear Field.

DISCIPLINE	Currently Employed			Planned 1970			Planned 1973		
	PhD	MS	BS	PhD	MS	BS	PhD	MS	BS
Nuclear Physics									
Thermonuclear Physics									
High Energy Physics									
Nuclear and Radiation Chemistry									
Reactor Engineering									
Other Nuclear Engineering									
Radiation Applications									
Health Physics									
Radiation Biology									

3. RESEARCH & DEVELOPMENT – FULL TIME
Please Enter Number of Personnel Employed and Planned for Research and Development in the Nuclear Field (not on teaching faculty).

DISCIPLINE	Currently Employed				Planned 1970				Planned 1973			
	PhD	MS	BS	Tech	PhD	MS	BS	Tech	PhD	MS	BS	Tech
Nuclear Physics												
Thermonuclear Physics												
High Energy Physics												
Nuclear and Radiation Chemistry												
Reactor Engineering												
Other Nuclear Engineering												
Radiation Applications												
Health Physics												
Radiation Biology												

3A. RESEARCH & DEVELOPMENT – PART TIME
Please Enter Number of Personnel Employed and Planned for Research and Development in the Nuclear Field (not on teaching faculty).

DISCIPLINE	Currently Employed				Planned 1970				Planned 1973			
	PhD	MS	BS	Tech	PhD	MS	BS	Tech	PhD	MS	BS	Tech
Nuclear Physics												
Thermonuclear Physics												
High Energy Physics												
Nuclear and Radiation Chemistry												
Reactor Engineering												
Other Nuclear Engineering												
Radiation Applications												
Health Physics												
Radiation Biology												

4. NUCLEAR FACILITIES – FULL TIME
Please Enter Number of Personnel Employed and Planned for Operation of Nuclear Facilities (not on teaching faculty).

AREA	Currently Employed				Planned 1970				Planned 1973			
	PhD	MS	BS	Tech	PhD	MS	BS	Tech	PhD	MS	BS	Tech
Reactor Supervisors												
Reactor Operators												
Accelerator Supervisors												
Accelerator Operators												
Radiation Safety Officer (Health Physicist)												

4A. NUCLEAR FACILITIES – PART TIME
Please Enter Number of Personnel Employed and Planned for Operation of Nuclear Facilities (not on teaching faculty).

AREA	Currently Employed				Planned 1970				Planned 1973			
	PhD	MS	BS	Tech	PhD	MS	BS	Tech	PhD	MS	BS	Tech
Reactor Supervisors												
Reactor Operators												
Accelerator Supervisors												
Accelerator Operators												
Radiation Safety Officer (Health Physicist)												

5. STUDENT ENROLLMENT
Please Enter Number of Students Enrolled and Planned by Degree Currently Being Sought.

DISCIPLINE	Current			Planned 1970			Planned 1973		
	PhD	MS	BS	PhD	MS	BS	PhD	MS	BS
Nuclear Physics									
Thermonuclear Physics									
High Energy Physics									
Nuclear and Radiation Chemistry									
Reactor Engineering									
Other Nuclear Engineering									
Radiation Applications									
Health Physics									
Radiation Biology									

6. DEPARTMENTS
Please List Current and Planned Departments by Name Offering Nuclear Courses and Add Number of Courses for Each.

DEPARTMENT	No. of Courses – Undergraduate			No. of Courses – Graduate		
	1967	1970	1973	1967	1970	1973

7. Please List Nuclear Facilities and Major Equipment Acquisitions Planned. List Only Those Items Costing $25,000 or More Including Those for Academic Year 1967-68.
PLANNED FACILITIES + EQUIPMENT

By 1970	By 1973

Name _____ Title _____
(PERSON TO CONTACT FOR FURTHER INFORMATION)

When completed this questionnaire should be returned in attached envelope to:

OCTAVE J. DU TEMPLE, EXECUTIVE SECRETARY
AMERICAN NUCLEAR SOCIETY
244 EAST OGDEN AVENUE
HINSDALE, ILLINOIS 60521

November 1967

★ U. S. GOVERNMENT PRINTING OFFICE : 1971 436-230/257